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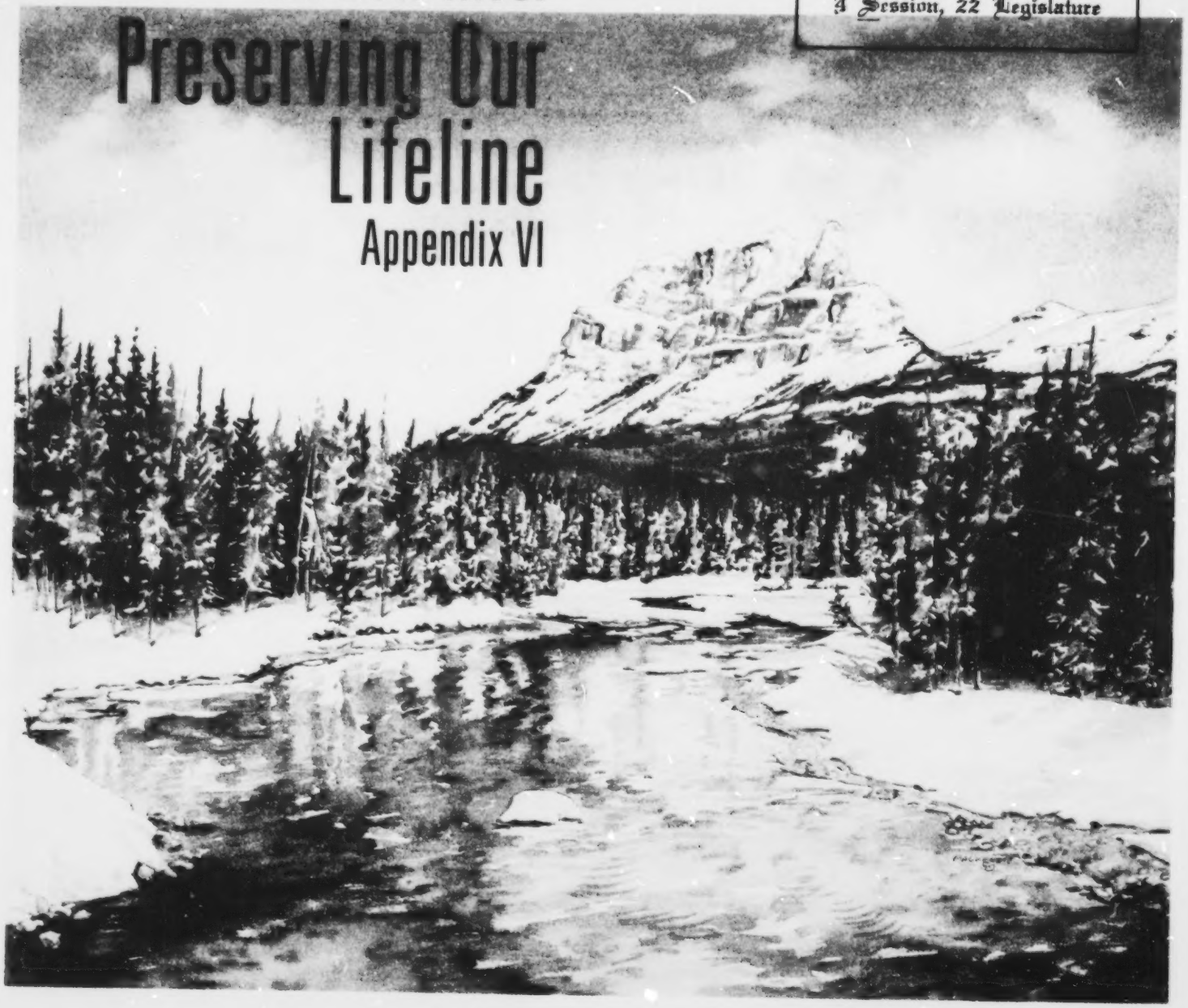
The Bow River

Preserving Our Lifeline

Appendix VI



Report of the

Bow River
WATER QUALITY
TASK FORCE

November 1991

Cover painting *Headwaters of the Bow* by Cynthia Mackenzie.

Cynthia Mackenzie was born in Vancouver and graduated from the Alberta College of Art Fine Arts program in 1975.
Her delicate and detailed watercolors are represented in collections in Canada, the United States and Europe.

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THE BOW RIVER

PRESERVING OUR LIFELINE

APPENDIX VI - TECHNICAL INFORMATION

Appendix VI is a compilation of working documents prepared by and made available to the Bow River Water Quality Task Force. It contains information obtained from Task Force members, consultants, and government agencies. This information was used by the Task Force to assist in (1) identification of water quality problems, (2) identification of causes of those problems, and (3) formulation of its recommendations. If discrepancies exist between this Appendix and the main report, then the main report should be considered to represent the final views of the Task Force.

Report of
The Bow River
Water Quality Task Force
November 1991

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1.0 USE-SPECIFIC WATER QUALITY GOALS AND OBJECTIVES

This appendix presents the technical objectives which reflect the water use specific goals and objectives put forward by the Bow River Water Quality Task Force. They are required in order to allow evaluation of the existing water quality status of the Bow River on a reach-specific basis. The criteria for selection of these technical objectives, and corresponding limitations are as follows.

SELECTION CRITERIA

- reflect the intent of the vision statement
- allow for detection of all potential water quality impacts, i.e., municipal wastes, industrial wastes, urban runoff, agricultural runoff, contaminated industrial sites
- be water use specific
- integrate with the database to priorize impacts on water use.

LIMITATIONS

- be largely based upon existing criteria and objective documents pertinent to the Bow River as there is no time to formulate new site specific water quality objectives from either review of the scientific literature or basic research.
- Criteria and Objective Documents considered were:
  - Alberta Surface Water Quality Objectives, Water Quality Branch, Standards and Approvals Division, Alberta Environment, 1977 (1)
  - Canadian Water Quality Guidelines, Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers, 1987 (2)
  - Alberta Agriculture Guidelines for Irrigation Water Quality, Agdex 562-1, 1983 and
  - Alberta Agriculture Chemical Analysis of Water for Livestock Use, Agdex 400/65-1, 1978 (3)
  - South Saskatchewan River Basin Planning Program (SSRBPP) - Application of Water Quality Criteria to the SSRBPP, Alberta Environment, Pollution Control Division, Water Quality Control Branch, 1983 (4)
  - Temperature and Oxygen Objectives Developed for Highwood and Oldman Rivers (5)
  - Professional Opinion (6)
  - Guidelines for Canadian Drinking Water Quality, Federal-Provincial Working Group on Drinking Water of the Federal-Provincial Advisory Committee on Environmental and Occupational Health. (7)
  - Guidelines for Canadian Drinking Water Quality, Federal-Provincial Subcommittee on Drinking Water of the Federal-Provincial Advisory Committee on Environment and Occupational Health, 1989 (8)
- number and range of objectives must be restricted; where possible "indicator parameters" are used to represent quality for entire group of contaminants, e.g., presence of pathogenic bacteria and viruses evaluated by the fecal coliform test
- interface with available monitoring data

In the sections which follow, the technical criteria for each water use are presented in tables, while comments pertinent to their selection are documented in point form. In some cases it is not possible to define specific technical objectives in terms of contaminant concentrations, therefore some objectives can only be presented as narrative statements.

1.1 Municipal and Domestic Water Supply (Table 1)

The comments which follow on the linkage between raw water quality and requirements for water treatment are drawn from CCREM (2) and discussions with Municipal Branch, Standards and Approvals Division, Alberta Environment (D. Spink and J. Milos, personal communication).

The primary objective of drinking water treatment is the production of an aesthetically pleasing water that is free of pathogenic organisms and harmful chemicals. The poorer the quality of the source water, the greater the number of treatment barriers (treatment steps) that must be incorporated into the treatment process. It is generally recognized that good quality drinking water can be produced from almost any water source, providing that the appropriate technology is used.

Because the Federal-Provincial Subcommittee on Drinking Water (2) considers all waters can be treated to drinking levels, treatment-specific numeric objectives for raw public water supplies have not been developed by CCREM (2). They have only developed treated water guidelines. The raw water guidelines presented here have been synthesized specifically for the Bow River Task Force. As one moves from Level I through Level III it indicates that there may be a need for more advanced treatment to bring the quality up to the Canadian Drinking Water Guideline levels (8)

Water that is equal to or better than the Level I numeric objectives is of high quality and the bacteriological indicators are low enough that the risk of pathogenic contamination from bacteria is probably low. The chemical objectives for Level I water are all based upon the existing and proposed maximum acceptable or aesthetic drinking water guidelines (8). Level I water must also not be contaminated with trace organic compounds such as herbicides and pesticides.

Although Level I water is of high quality it still must be disinfected prior to use. However, simple disinfection may not eliminate the risk of infection with the protozoan cysts such as Giardia. In fact, no matter how good the raw water quality, for elimination of Giardia all water supplies should receive at least chemical pretreatment. It must be emphasized, that no untreated waters are safe to drink, and that water treatment systems must be designed to treat water of the worst possible quality that can be expected, a concept applied in Alberta. This dictates the use of off-stream storage works or full conventional treatment facilities even if the water quality may be Level I virtually all of the time.

Significant algal levels can affect water quality conditions including taste and odour, colour, anoxic condition, etc.; therefore we have also set the Level I chlorophyll a and phosphorus limits to reflect low levels of algal productivity (i.e. oligotrophic). In smaller centres, Alberta Environment has previously defined pressure filtration followed by disinfection as minimum conventional treatment. They are now moving toward requiring chemical addition to assist the filtration process.. Slow sand filtration, provided it is properly constructed and operated, is another option that may be available to small communities with good (consistentt) quality surface water sources.

Level II reflects water of good to moderate quality. Raw waters that fall in this category should receive conventional treatment, which for large municipalities is considered to be coagulation-flocculation, sedimentation, filtration and disinfection. Bacteriological levels indicate a moderate degree of direct or indirect contamination. Very low turbidity levels must be achieved to ensure adequate destruction of pathogens during the disinfection process, and it is assumed that some control of colour can be achieved with conventional treatment. Raw water parameters such as trace metals and other contaminants associated with particles can be somewhat elevated relative to the Drinking Water Guidelines, as they will be removed by sedimentation and filtration. However, we have assumed no dissolved parameters will be removed during treatment, therefore Level II dissolved salts and trace organic compounds must essentially meet drinking water guidelines. Some algae will be removed by conventional treatment, therefore taste and odour should not be a significant problem at moderate chlorophyll and nutrient levels.

The Level III category includes waters that are of poor quality due to natural or anthropogenic

Table 1. Technical Definition of Levels of Raw Water Quality for Domestic and Municipal Supply.

	Level I	Level II	Level III	(Source)
Total Coliforms (counts/100 mL)	<100	100 - 1000	>1000	(7)
Fecal Coliforms (counts/100 mL)	<10	10 - 100	>100	(7)
Turbidity (JTU)	<10	>10	N/A	(6)
Colour (TCU)	<15	<50	>50	(6)
pH	>6.5-8.5	<6.5-8.5	N/A	(8)
TDS (mg/L)	<500	<500	>500	(8)
Sodium	<200	<200	>200	(8)
Sulphate	<500	<500	>500	(8)
Arsenic (mg/L)	<0.05	>0.05	N/A	(8)
Barium (mg/L)	<1.0	>1.0	N/A	(8)
Boron (mg/L)	<5.0	<5.0	>5.0	(8)
Cadmium (mg/L)	<0.005	>0.005	N/A	(8)
Chloride (mg/L)	<250	<250	>250	(8)
Chromium (mg/L)	<0.05	>0.05	N/A	(8)
Copper (mg/L)	<1.0	>1.0	N/A	(8)
Fluoride (mg/L)	<1.5	<1.5	>1.5	(8)
Iron (mg/L)	<0.3	>0.3	N/A	(8)
Lead (mg/L)	<0.01	>0.01	N/A	(8)
Manganese (mg/L)	<0.05	>0.05	N/A	(8)
Mercury (mg/L)	<0.001	>0.001	N/A	(8)
Nitrate (mg/L)	<10	<10	>10	(8)
Selenium (mg/L)	<0.01	>0.01	N/A	(8)
Zinc (mg/L)	<5	>5	N/A	(8)
Chlorophyll a (mg/m^3)	<2	<25	>25	(6)
Total Phosphorus (mg/L)	≤0.010	<0.055	>0.055	(6)
Trace Organic Contaminants	ABS	ABS	PRES	(2)

ABS = Absent PRES = Present or High Likelihood of Occurrence N/A = Not Applicable

causes. With Level III water more than conventional treatment may be required to either 1) remove salts, 2) remove specific trace organic contaminants, or 3) control taste and odour problem. High fecal or total coliform levels in Level III water could be due to effluent discharges or agricultural runoff. Similarly, high turbidity means care in treatment is required to facilitate the filtration and disinfection process. Waters that exhibit very high algal production (chlorophyll and phosphorus levels) can cause taste and odour problems. Waters that have measurable levels of trace organics, like herbicides and pesticides, would also fall into the Level III category. Examples of advanced treatment technologies that can be used for Level III waters are pre-ozonation, carbon adsorption, air stripping, reverse osmosis and ion exchange.

1.2 Recreation and Aesthetic Enjoyment (Table 2)

Contact Recreation

The Task Force considers all recreational activities which involve being in or on the water as contact, therefore, a separate set of objectives for non-contact recreation is not required.

General requirements for contact recreation are:

a. aesthetics; water should be free from obnoxious floating or suspended substances, objectionable colour, scums or odours;

b. toxins; water should be free of any substances toxic upon ingestion or irritating to the human skin;

c. pathogens; waters must be reasonably free of disease-causing organisms.

Coliforms (a group of easily cultured bacteria many of which are found in the guts of humans and other animals) act as simple indictors of possible sewage contamination and, therefore, the possible presence of infectious organisms. Fecal coliforms are a sub-group of coliforms more strongly indicative of fecal contamination. For contact recreation, fecal coliforms should be $<200/100$ mL, and total coliforms $<1000/100$ mL (CCREM (2); ASWQO (1)).

Standards for turbidity and suspended solids are based on need to maintain water clarity so that underwater hazards or swimmers in trouble may be easily seen. CCREM (2) recommends that a Secchi disc (a highly visible white and black disc which measured clarity) be visible to a depth of 1.2 m or more.

Alberta (1) and SSRBPP (4) objectives allow turbidity to increase <25 Jackson Turbidity Units (JTU), (an arbitrary scale) above natural, and suspended material may increase <10 mg/L over background. Such relative measures are unsuitable for contact recreation, where for aesthetic and safety reasons the absolute water clarity is of importance.

Water should be free of objectionable odours. The Alberta objective is that the cold (20°C) threshold odour number be <8 (an arbitrary scale). Unfortunately, this test is no longer included in monitoring programs.

Dense growths of algae may form unsightly scums and produce foul odours upon decomposition. The objectives for aquatic plants and benthic algae (chlorophyll) in rivers are adapted from the SSRBPP objectives (4). They allow for some growth, but not dense enough beds to be offensive or cause entanglement. The algal (chlorophyll) objective for lakes and reservoirs is a moderate amount of growth (mesotrophic) and the total phosphorus levels correspond to the amount necessary to support such growth.

- Very high or very low pH waters may be stressful to the human eye, especially if the buffering capacity of the water is also high (CCREM (2)).

- Water of 20-30°C is considered comfortable for swimming, but many individuals tolerate much colder water. Water temperature is not included since the Task Force's definition of contact recreation does not just include swimming.

Aesthetic Enjoyment

- Within the Bow River Basin, excessive weed and algal growth is probably the primary aesthetic impact. It affects water clarity and can cause secondary impacts like odour due to decaying vegetation.

Table 2. Technical Objectives in Support of Water Quality Goals for Recreation and Aesthetic Enjoyment.

Task Force Goals and Objectives	Water Quality Parameter	Maximum Permissible Concentration	Source
Contact Recreation			
- small risk of bacterial or viral infection	Fecal Coliforms	200 counts/100 mL	(1) (2)
- high degree of water clarity	Total Coliforms	1000 counts/100 mL	(1)
- no excessive weed or algal growth	Secchi Depth	> 1.2 m	(2)
- no odour or oil sheen	Turbidity	50 NTU	(2)
- no hazardous chemicals	pH	8.5 units	(2)
	River Aquatic Plants	75 gm/m^2 dry wt	(4) (6)
	River Benthic Chlorophyll	50 mg/m^2	(4) (6)
	Lake/Reservoir Chlorophyll	15 mg/m^3	(4) (6)
	Lake/Reservoir Total Phosphorus	40 µg/L	(4) (6)
Aesthetic Enjoyment			
- weed and algal growth that is not unsightly	River Aquatic Plants	200 gm/m^2 dry wt	(4) (6)
- no odour or oily sheen	River Benthic Chlorophyll	100 mg/m^2	(4) (6)
	Lake/Reservoir Chlorophyll	25 mg/m^3	(4) (6)
	Lake/Reservoir Total Phosphorus	55 µg/L	(4) (6)

The aquatic plant and algal densities (chlorophyll) are adapted from the SSRBPP (4) objectives and consider that marginally greater growth is appropriate for aesthetics relative to contact recreation.

A direct objective for water clarity (secchi depth or turbidity) is not recommended due to the high degree of natural variability across the basin.

1.3 Ecosystem (Table 3)

Guidelines and objectives for protection of aquatic life have been developed by CCREM (2), Alberta (1) and the SSRBPP (4).

These are intended to protect aquatic life and maintain ecosystem integrity by:

1. maintaining background water conditions (temperature, dissolved oxygen, pH, hardness, alkalinity) within the range conducive to organism survival and to which the local species are adapted;
2. preventing toxic effects of heavy metals, industrial chemicals and other human-caused pollutants;
3. controlling nutrients, principally nitrogen and phosphorus, to levels that do not promote rapid growth of algae and aquatic plants and the changes in ecosystem structure that result (eutrophication).

warm water species require different temperature and oxygen regimes and these have been recognized in defining the technical objectives.

Salinity is rarely toxic (except in extremely salty water), so no objectives have been defined at this time.

Major ions (calcium, magnesium, sodium, sulphate, bicarbonate, chloride) vary too widely to allow guidelines to be established (Standards and Approvals Division, 1977).

The pH (relative dominance of acids or bases) is a critical parameter; most organisms are adapted to a relatively narrow pH range, and some life stages (e.g. fish eggs) are very sensitive to pH changes. The usual pH range is 6.5 (slightly acidic) to 8.5 (strongly basic) (CCREM recommends maximum of 9). In addition, Alberta stipulates that pH should not be changed >0.5 units from the seasonal minimum or maximum (Standards and Approvals Division, 1977; Hamilton, 1983).

Total suspended solids (TSS) measures mass of particles, mostly silt and clay, in suspension. They interfere with vision and light penetration, clog gills, settle and coat bottom habitat and may carry metals or organic toxins adsorbed to the surface. However, TSS levels vary naturally over a wide range; thus objectives must specify change from background. Such an evaluation is beyond the scope of this exercise.

Temperature is a complex parameter; setting simple objectives is difficult. Temperature requirements for fish and stream insects (etc.) depend upon the maximum or minimum temperature itself, its duration, the frequency of cold or warm spells and the rate of temperature change. Sensitivity to temperature depends on species, life stage (egg, larva, juvenile, adult), season, and general health of the organism. Changes in the mean seasonal temperature or changes in the timing of seasonal temperature changes can affect aquatic organisms by changing metabolic rates, accelerating (or decelerating) life cycles, and disrupting cues for behaviour such as feeding, spawning and migration. Cold-water ecosystems, such as the upper Bow River, tend to have sharply different species assemblages from warm-water systems found downstream. Cold-water species and systems usually tolerate a narrower range of temperatures and are more sensitive to temperature changes. The water quality objective defined here is the daily maximum, and is intended as an indicator of heat stress.

Like temperature, dissolved oxygen (DO) is a complex parameter. Solubility of oxygen in water varies inversely with temperature; saturation is >14 mg/L at 0°C, but only 8.3 mg/L at 25°C. DO is added to water by diffusion from the atmosphere and photosynthesis; and removed by plant respiration and decomposition of organic matter. DO levels may thus vary between day and night because of the changing balance of photosynthesis and respiration. Organisms demand for DO varies with species habitat, life stage and temperature. Species living in warm, slow-moving water tend to be

Table 3. Technical Objectives in Support of Water Quality Goals for the Ecosystem.

Task Force Goals and Objectives	Water Quality Parameter	Maximum Permissible Concentration	Source
Cold Water Aquatic Ecosystem - non-toxic to aquatic life - cool water temperatures - high oxygen content - diverse cold water plant and invertebrate community - fish tissue with no unpleasant taste or odour, and that complies with human guidelines for consumption	Dissolved Oxygen	>6.5 mg/L	(5)
	Water Temperature	22°C	(5)
	pH	9.0 pH units	(2)
	Ammonia	0.32 mg/L	(2)
	River Benthic Chlorophyll	100 mg/m^2	(4) (6)
	River Aquatic Plants	200 gm/m^2 dry wt	(4) (6)
	Aluminum	0.1 mg/L	(2)
	Arsenic	0.05 mg/L	(2)
	Cadmium	0.0013 mg/L	(2)
	Chromium	0.002 mg/L	(2)
	Copper	0.003 mg/L	(2)
	Iron	0.3 mg/L	(2)
	Lead	0.004 mg/L	(2)
	Mercury	0.0001 mg/L	(2)
	Nickel	0.110 mg/L	(2)
	Zinc	0.03 mg/L	(2)
	Phenolic Compounds	0.001 mg/L	(2)
	2,4-D	0.004 mg/L	(2)
Warm Water Aquatic Ecosystem - moderate oxygen content - moderate water temperatures - non-toxic to aquatic life - diverse warm water plant and invertebrate community - fish tissue with no unpleasant taste or odour, and that comply with human guidelines for consumption	Dissolved Oxygen	>5.0 mg/L	(5)
	Water Temperature	29°C	(5)
	pH	9.0 pH units	(2)
	Ammonia	0.11 mg/L	(2)
	River Benthic Chlorophyll	100 mg/m^2	(4) (6)
	River Aquatic Plants	200 gm/m^2 dry wt	(4) (6)
	Aluminum	0.1 mg/L	(2)
	Arsenic	0.05 mg/L	(2)
	Cadmium	0.0013 mg/L	(2)
	Chromium	0.002 mg/L	(2)
	Copper	0.003 mg/L	(2)
	Iron	0.3 mg/L	(2)
	Lead	0.004 mg/L	(2)
	Mercury	0.0001 mg/L	(2)
	Nickel	0.110 mg/L	(2)
	Zinc	0.03 mg/L	(2)
	Phenol	0.001 mg/L	(2)
	2,4-D	0.004 mg/L	(2)
Wildlife	- Equal to Aquatic Ecosystems	- Equal to Aquatic Ecosystems	(6)

adapted to lower DO levels than those living in cold, fast-moving water. Oxygen requirements of aquatic insects and most non-fish organisms are not well-known. Higher concentrations (>8.0 mg/L) are necessary where trout spawn, to ensure sufficient oxygen reaches the eggs buried in the bottom gravel. Maximum concentrations of DO, or other dissolved gases (O_2 etc.) should not exceed 110% of their saturation value (4). Supersaturation of water with oxygen may be a problem where algal or rooted aquatic plant growth is dense. The oxygen objectives set here are intended as indicators of potential oxygen stress.

Excess of phosphorus leads to eutrophication:

- plant production increases, and the biomass of other trophic levels may also increase
- increased photosynthesis and increased DO demands for decomposition cause widely varying DO concentrations
- species richness of the ecosystem tends to decrease; diversity declines
- in the extreme, only a few hardy species persist, plant or algal growth may be unsightly, and low DO and decaying organic matter release toxins or cause foul odours
- in the technical objectives we have included direct measures of benthic algae (chlorophyll) and aquatic plants as indicators of eutrophication

Ammonia (NH_3) is a form of nitrogen that is important as a potential toxicant. Only the un-ionized form is toxic; proportions of ionized and un-ionized ammonia vary predictably according to pH and temperature, with greatest toxicity in warm, basic (pH >7) water. The objective values are intended as worst case indicators. For cold water we assumed a pH of 8.5 and 20°C temperature; for warm water we assumed a pH of 8.75 and 30°C temperature.

A long list of metals may be present in contaminated surface waters, and most are toxic at concentrations substantially higher than their naturally occurring levels. The objectives for metals are primarily from CCREM (2). Guidelines for some metals vary with pH or water hardness; therefore conditions typical of the Bow River were used to select objectives. Where ASWQO and CCREM guidelines disagree, the latter have been preferred, as they include somewhat more recent research.

The CCREM (2) guidelines include 25 trace organic compounds, pesticides and industrial or sewage contaminants, many of which are not routinely monitored in the Bow River. The herbicide 2,4-D is often tested for and therefore a limit has been identified.

1.4 Agriculture (Table 4)

Irrigation

The most important parameters with respect to crop yield impairment are total ion content (salinity) and the proportion of sodium. Concentration limits are generally based on continual application for 20-100 years. There is great variation among crop species in their tolerance of irrigation waters of differing qualities. Therefore, objectives for the Bow River are generally based on the more sensitive species grown. Soil texture is also a critical determinant of tolerable water quality. Generally, lower quality water (i.e. more saline) may be more readily applied to sandy, well-drained, slightly acidic soils than to clay-based, poorly drained, neutral or alkaline soil. Common problems arising from use of salty water for irrigation are:

- accumulations of salts in the root zone which inhibit plant growth by limiting their ability to extract water;
- loss of water permeability from excess sodium or leaching of calcium; and
- direct toxicity of salts, trace elements or pesticides.

Total dissolved solids (salinity) of irrigation water can vary from <500 mg/L to 3500 mg/L, depending on crop concerned; the most sensitive crops are berries, beans, and carrots. Alberta Agriculture (3) defines salinity in terms of

Table 4. Technical Objectives in Support of Water Quality Goals for Agricultural Use.

Task Force Goals and Objectives	Water Quality Parameter	Maximum Permissible Concentration	Source
Irrigation Water - low salt content - trace metal and herbicide levels which are non-toxic to plant growth - no bioaccumulative contaminants or pathogenic organisms - low to moderate river plant and algal growth - nutrient levels which do not stimulate nuisance plant growth in conveyance canals	Total Dissolved Solids	700 mg/L	(2)
	Electrical Conductivity	1.0 ms/cm	(3)
	Sodium Adsorption Ratio (SAR)	4	(3)
	Boron	0.5 mg/L	(1) (2)
	Aluminum	5.0 mg/L	(2)
	Arsenic	0.1 mg/L	(2)
	Chromium	0.1 mg/L	(2)
	Copper	0.2 mg/L	(2)
	Cobalt	0.05 mg/L	(2)
	Fluoride	1.0 mg/L	(2)
	Iron	5.0 mg/L	(2)
	Manganese	0.2 mg/L	(2)
	Nickel	0.2 mg/L	(2)
	Zinc	1.0 mg/L	(2)
	2,4-D	0.1 mg/L	(2)
	Total Coliform Bacteria	1000/100 mL	(1)
	Fecal Coliform Bacteria	200/100 mL	(1)
	Cadmium	0.2 mg/L	(2)
	Lead	0.2 mg/L	(2)
	Selenium	0.02 mg/L	(2)
	River Benthic Chlorophyll	100 mg/m^2	(4)
	River Aquatic Plants	200 gm/m^2 dry wt	(4)
	Total Phosphorus	0.025 mg/L	(4)
Livestock Watering - no bioaccumulative contaminants or pathogenic bacteria - low to moderate salt content - non-toxic levels of nitrogen, pesticides and trace metals - nutrient levels which do not stimulate growth of toxic blue-green algae	Total Dissolved Solids	1500 mg/L	(3) (4)
	Nitrate + Nitrite	100 mg/L	(3)
	Total Phosphorus	0.100 mg/L	(6)
	Sulphate	1000 mg/L	(2)
	Aluminum	5.0 mg/L	(2)
	Arsenic	0.5 mg/L	(2)
	Boron	5.0 mg/L	(2)
	Chromium	1.0 mg/L	(2)
	Cobalt	1.0 mg/L	(2)
	Copper	0.5 mg/L	(2)
	Fluoride	1.0 mg/L	(2)
	Nickel	1.0 mg/L	(2)
	Selenium	0.05 mg/L	(2)
	Zinc	50 mg/L	(2)
	Cadmium	0.02 mg/L	(2)
	Lead	0.1 mg/L	(2)
	Mercury	0.003 mg/L	(2)

electrical conductivity (also called specific conductance), which is the ability of a solution to carry an electrical current. Conductivity varies directly with salinity, and it is easier to measure than salinity. Alberta Environment defines water as "safe" for all irrigation if its conductivity is < 1.0 mS/cm, and "possibly safe" if < 2.5 mS/cm. (1 mS/cm = 1 microSieman/ centimetre = about 700 mg/L total dissolved solids).

Sodium is important as a direct plant toxicant, and because of its potential effects on soil structure. However, toxicity of sodium is often difficult to separate from that of total salinity. An important measure is the ratio of sodium to calcium and magnesium, as calculated by the Sodium Absorption Ratio (SAR):

$$SAR = Na^{+} / ((Ca^{2+} + Mg^{2+}) /2)^{1/2}$$

when concentrations are expressed as mg/L. High SAR causes deterioration of soil structure, breakdown of clay granules, and a resultant loss of permeability to water and air. SAR <4 is considered safe on all soils; SAR 4-9 is considered risky but may be used depending on soil type, climate and irrigation regime, SAR>9 will cause soil problems and should not be used (CCREM (2) and Alberta Agriculture, (3)).

CCREM (2) gives guidelines for 19 trace metals that could be toxic to plants. Most of these are not generally a problem in Alberta; Alberta Agriculture (3) mentions only Boron, for which toxic levels are not often found in Alberta surface waters. Concentrations of many metals are reduced in soil because of binding to soil particles. Crop species, soil type and irrigation regime all affect the toxicity of trace metals, and concentrations higher than those shown may often be tolerated.

- Higher levels (to 1.0 mg/L) of arsenic may be tolerated in clay soils.

- Tolerance to boron varies widely among plant species; potatoes and wheat are quite sensitive, and can tolerate 0.5-1.0 mg/L without reduction in yield (CCREM, (2)). Alberta Surface Water Quality Guideline for boron is 0.5 mg/L.

- Cadmium is toxic to plants and animals and accumulates in plant tissue.

- Chromium is toxic at high concentrations but beneficial to plants at low concentrations.

- Copper is an essential element, and Alberta soils may be copper-deficient. High concentrations are toxic. Cereal crops are insensitive to copper, and a guideline of 1.0 mg/L is recommended for these crops.

- Dissolved iron in irrigation water precipitates upon aeration, and may coat leaves, clog irrigation equipment and bind phosphorus.

- Lead may accumulate in edible plant parts, and is toxic to humans.

- Manganese is only potentially a problem on acidic soil.

- Molybdenum and selenium are not toxic to the plants themselves, but may be a hazard to livestock that feed on them.

There is no data to suggest that insecticide residues are harmful to plants; therefore no guideline is recommended (CCREM, (2)). Herbicides may enter irrigation water if they are applied to ponds or ditches (including banks) to control weed or algae growth. Based on data in CCREM (1987; Tables 4-9), only Simazine (applied to water) and 2,4-D (applied to river banks) have any significant chance of occurring in irrigation water at concentrations harmful to crops. These chemicals should be present at concentrations <0.1 mg/L in irrigation water. Alberta Surface Water Quality Objectives recommends that the concentration of carbon-chloroform extractibles be <0.2 mg/L. This fraction includes most herbicides, insecticides and some industrial chemicals, however, it is not normally monitored for so it is not included in Table 4.

Crops and vegetables can become contaminated from irrigation water containing human and animal pathogens or parasites. These in turn can be taken up by people from vegetables surfaces, and by animals in their feed. Fecal coliform bacteria, a group of common and easily identifiable organisms, are

used as indicators of the possible presence of more injurious organisms. The general Alberta Surface Water Objective for coliforms is complex:

- geometric mean of >5 samples/month should be <1000 / 100 mL for total coliforms and <200 / 100 mL for fecal coliforms;
- above figures should be exceeded in ≤ 20% of samples each month;
- samples on any one day should not exceed 2400 total coliforms per 100 mL.

Reliance on geometric mean and multiple samples per month arises because populations of bacteria in surface water may change quickly.

Nutrients are not mentioned in most existing water quality guidelines because these deal only with the quality of water for irrigation itself, i.e., effects on plants or soil. But one must also consider effect of high nutrient contents (nitrogen and phosphorus) on promoting plant growth that congests irrigation canals and reduces water quality in reservoirs. Phosphorus is the more important nutrient, and total phosphorus (TP) shows the best correlation with algal or rooted plant growth. TP guidelines usually vary between standing water (lakes, reservoirs) and flowing water (rivers, streams). Here, it is best to apply standing-water criteria, to cover both reservoirs and smaller canals, in which water currents may be quite slow.

STOCK WATERING

- Total dissolved solids content (TDS) is the most important consideration for livestock water. According to Alberta Agriculture, water with TDS of <1500 mg/L, is excellent for all animals. Water with TDS concentrations 1500-5000 mg/L is usable by most farm animals but is too saline for poultry. SSRBPP (4) sets two limits, at 1500 and 5000 mg/L, as above. CCREM (Table 4-13) sets 3000 mg/L as the numerical limit, but notes that water near the limit is unsuitable for poultry.
- Nitrite (NO_2) is highly toxic, and prevents uptake of oxygen by the blood; nitrite should be <10 mg/L (CCREM (2); Alberta Agriculture (3)). Nitrate is a stomach irritant, and may be converted to nitrite by ruminants. The nitrate objective is 100 mg/L for stock watering (Alberta Agriculture (3)). It includes $NO_3 + NO_2$ when measured together (CCREM, 1987).
- CCREM (2) also includes guidelines for a long list of heavy metals and trace ions. These are usually much higher than the guidelines for drinking water or protection of aquatic life.
- Water for livestock should be of high bacteriological quality to avoid transmission of disease, and should have total phosphorus levels below those needed to produce heavy growth of blue-green algae (produce toxins).

1.5 Water Disposal

- It is not possible to set general river water quality objectives for this water use category.

1.6 Industry (Table 5)

- The primary concern is weeds and algae clogging water withdrawal facilities. The limits set for aquatic plants and algae reflect a moderate level of growth.

1.7 Hydro-Power Generation

- It is not possible to set general river water quality objectives for this water use category.

Table 5. Technical Objectives in Support of Water Quality Goals for Industrial Use.

Task Force Goals and Objectives	Water Quality Parameter	Maximum Permissible Concentration	Source
Industry			
- maintain low to moderate weed and algal growth so water withdrawal is not impaired	River Benthic Chlorophyll River Aquatic Plants	100 mg/m^2 200 mg/m^2 dry wt	(4) (6) (4) (6)

2.0 IDENTIFICATION OF POLLUTANTS AND IMPACTS

2.1 Summary

This section of the Appendix summarizes the existing problems with water quality along the Bow River and presents the information used to identify those problems. Existing problems along the Bow River were identified by obtaining first hand information from Task Force members, testing data from river and drinking water monitoring programs against available water quality objectives and guidelines, and by reviewing technical documents. The review of technical data and documents focussed on monitoring data collected since 1985 and documents prepared from 1980 to 1991. That information is summarized on the following pages for each of the eight reaches of the Bow River and is provided in more detail in the following sections. The citations in the summaries refer to either table numbers (for those items under "Monitoring Data Review") or references (for those items under "Technical Report Review").

REACH 1 WATER QUALITY IMPACT SUMMARY HEADWATERS TO U/S LAKE LOUISE

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
Giardia	Level I (Table 6)	- Natural levels of bacteria (33, 32, 31) - Untreated water is not suitable for human consumption or domestic purposes because of microbiological agents (38)	- No information on *Giardia* levels
Recreation and Aesthetic Enjoyment			
No problems at present	- No exceedances of objectives (Table 6) - Low aquatic plant and benthic algal densities (Table 17)	- Low nutrient and bacteria levels (33)	
Ecosystem (Cold Water)			
No problems at present	- No exceedances of objectives (Table 6) - Low aquatic plant and benthic algal densities (Table 17)	- Water quality is excellent (33)	- Excellent habitat for aquatic organisms
Agriculture			
N/A	N/A	N/A	
Industry			
N/A	N/A	N/A	

REACH 2: WATER QUALITY IMPACT SUMMARY - LAKE LOUISE TO BANFF PARK BOUNDARY (including Spray River).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
- *Giardia* - Salts (perceived)	- Level I (Table 7)	- In the early 1980's Louise Creek, Baker Creek, Spray River, Sunshine Creek,, Bow River d/s Banff sometimes exceeded objectives for coliform bacteria (33, 32, 31). - Renovations of Lake Louise and Banff sewage treatment plants have improved effluent quality (32, 29) - Untreated water not suitable for human consumption or domestic purposes due to microbiological agents (38)	- No information on *Giardia* levels or salt from road runoff
Recreation and Aesthetic Enjoyment			
- Health risks - Coliform bacteria - Algal growth in river	- No exceedances of objectives (Table 7) - Low aquatic plant and benthic algal densities in Bow River (Table 17)	- See above - Prolific benthic algal growth in Louise Creek immediately below discharge from Chateau Lake Louise's heating plant (33) - Bow Lake and Lake Minnewanka are of excellent quality (33)	- Bacteria levels high d/s of sewage outfalls - No apparent problems with algal growth in river
Ecosystem (Cold Water)			
- Algal growth	- No exceedances of objectives (Table 7) - Low aquatic plant and benthic algal densities (Table 17)	- Prolific benthic algal growth in Louise Creek immediately below discharge from Chateau Lake Louise's heating plant (33)	- Excellent habitat for aquatic organisms

REACH 2 WATER QUALITY IMPACT SUMMARY (concluded)

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Agriculture			
N/A	N/A	N/A	
Industry			
N/A	N/A	N/A	

REACH 3. WATER QUALITY IMPACT SUMMARY - BANFF PARK TO BEARSPAW DAM (including Ghost River, Spray Lakes and Kananaskis River).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
- Taste and odour and trace organics at Cochrane - Bacteria at Cochrane and Bearspaw Plant (real and perceived)	- Generally Level II (Table 8), although some trace organic compounds detected at Canmore, Cochrane, and Mount Allen (Table 16), - Rare exceedance of lead objective in Canmore drinking water (Table 15) - All drinking water guidelines met at Cochrane (Tables 15, 16)		- Insufficient monitoring data and lack of technical reports to address task force concerns - Ongoing monitoring of contaminated industrial site at Big Hill Creek, although no contaminants from that site have been detected in the Bow River
Recreation and Aesthetic Enjoyment			
- Turbidity in Ghost Reservoir, dust at Lac des Arcs and trash on banks - Coliforms at Cochrane	- Occasional exceedance of objectives for coliform bacteria at Cochrane (Table 8) - Low aquatic plant and algal densities in Bow River (Table 17)	- Slight increase in coliform counts at Cochrane in recent years (36)	- Lack of monitoring data and technical reports to address concerns re: Ghost Reservoir and Lac des Arcs - Monitoring data and technical reports support Task Force concern about coliform bacteria
Ecosystem (Cold Water)			
- No problems	- No exceedance of objectives (Table 8)	- No apparent limitation to fishery (24)	- Aquatic plants and algal densities suspected to be low, but no monitoring data available - No apparent problems

REACH 3. WATER QUALITY IMPACT SUMMARY (concluded).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Agriculture			
No problems	No problems for livestock watering (Table 8)		
Industry			
Siltation of intakes	Low aquatic plant and algal densities (Table 17)		Aquatic plant and algal densities suspected to be low, but no monitoring data available

REACH 4. WATER QUALITY IMPACT SUMMARY - BELOW BEARSPAW DAM TO WID WEIR (including Elbow River, Nose Creek, Western Irrigation District, and Chestermere Lake).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
- Health risks due to contaminants	- Rivers - generally Level II (Table 9) - WID system - mix of Levels II and III; Level III due to high phosphorus, bacteria and sodium (Table 9) - Measurable levels of PAH's and pentachlorophenol below Canada Creosote (Table 19) - Drinking water guidelines met at Airdire, Calgary, Gleichen, Standard, Strathmore (Tables 15 and 16)	- Glenmore Reservoir - elevated nutrients, bacteria, trace metals and salt (9, 7) - PCP and PAH's, with possible exception of benzo(a)pyrene, at insufficient levels to create health risk (3)	- Except for Canada Creosote study, no assessment of health risks due to contaminants
Recreation and Aesthetic Enjoyment			
- Coliforms, weeds, algae, debris in Chestermere Lake - High weed growth in WID canals - Debris and algae in river	- Limits for turbidity, phopshorus, coliform bacteria exceeded at some locations in WID (Table 9) - High turbidity in Elbow River (Table 9) - Low weed growth in Bow River (Table 17)	- Eagle Lake subject to high turbidity and algal blooms (25) - Troublesome algal growth in Nose Creek (21)	- No (or too few) monitoring data or technical reports to address concerns for Chestermere Lake or WID canals - Algal growth in river is low, no information on debris

REACH 4: WATER QUALITY IMPACT SUMMARY (concluded)

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Ecosystem (Cold Water)			
Potential fish tainting	- Exceedance of limits for phenols and selected metals in most surface waters (Table 9)	- PCB and pesticide residues low in fish (19, 2) - Detectable PCP and PAH's in fish tissue, but concentrations not high enough to pose health risk (3) - Temperature and oxygen stable and independent of flow variation (24) - Alum sludge from water treatment plants non-toxic (18); river disposal stopped (13)	- Fish tainting possibly a result of high phenolics levels
Agriculture			
Weeds in Chestermere Lake Silt deposits in canals	- No problems for livestock watering (Table 9) - Generally okay for irrigation except high phosphorus (Table 9)		- No monitoring data or technical reports to address Task Force concerns about weeds
Industry			
No problem	- Low weed growth in Bow River (Table 17)		- Aquatic plant and algal densities suspected to be low, but no monitoring data available

REACH 5. WATER QUALITY IMPACT SUMMARY - BELOW WID WEIR TO HWY 22.

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
- Organic contaminants, impact on downstream users	- Level III primarily due to phosphorus and coliform bacteria (Table 10) - Measurable levels of PAH's and pentachlorophenol in river (Table 19)	- Glenmore Reservoir - elevated nutrients, bacteria, trace metals and salt (9, 7) - PCP and PAH's, with possible exception of benzo(a)pyrene, at insufficient levels to create health risk (3)	- Except for Canada Creosote study, no assessment of health risks due to contaminants
Recreation and Aesthetic Enjoyment			
- Bacterial pollution, weed growth and oily smell	- High aquatic plant biomass in river in low flow years (Table 17) - Exceedance of coliform and pH objectives in river (Table 10)	- Aquatic plant production primarily controlled by physical variables at high flow (27); and nutrients at low flows (14) - No immediate change in aquatic plants following phosphorus control at Calgary, but anticipated (15, 36)	- No information on oily smells in river

REACH 5. WATER QUALITY IMPACT SUMMARY (concluded).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Ecosystem (Cold Water)			
Fish kills Fish taste and contamination suspected	Guidelines met (Table 10)	- PCB and pesticide residues low in fish (19, 2) - Potential ammonia toxicity below sewage treatment plants (26, 24) - Low nighttime oxygen levels created by weed growth in low flow years (24) - Detectable PCP and PAH's in fish tissue, but concentrations not high enough to pose health risk (3)	- No information on fish kills or taste, although contaminants in fish appear to be low
Agriculture			
Drying up of Fish Creek	- High macrophyte and algal growth in low flow years (Table 17) - Phosphorus and coliform objectives exceeded (Table 10) - No problems for livestock watering (Table 10)	- See comments under recreation and aesthetics	- No information on Fish Creek hydrology
Industry			
weeds and floating garbage, high conductivity	- High macrophyte and algal growth in low flow years (Table 17)	- See comments under recreation and aesthetics	- Monitoring and technical reports support Task Force concerns of weed growth - Conductivity in river and WID is low - No information on garbage

REACH 6. WATER QUALITY IMPACT SUMMARY - HWY 22 TO CARSELAND WEIR (including Sheep and Highwood Rivers and Bow River Irrigation District.

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
- Toxic metals, coliform bacteria, health effects	- Level III in Bow River, lower reaches of tributaries, and canals primarily due to phosphorus and coliform bacteria (Table 11) - Measurable levels of PAH's and pentachlorophenol (Table 19) - Iron levels at Turner Valley and Black Diamond and manganese levels at Enchant and Lomond exceed guidelines (Table 15) - All drinking water guidelines met at Badger Lake, High River, Longview, Okotoks, Hays (Tables 15 and 16)	- PCP and PAH's at insufficient levels to create health risk (3)	- Monitoring data and technical reports indicate treated water is safe to drink
Recreation and Aesthetic Enjoyment			
- Swimmer's itch, bacteria and weeds, bank erosion and turbidity	- Moderate aquatic plant biomass in low flow years (Table 17)	- See comments for Reach 5	- No information on swimmer's itch - Task Force concerns about bacteria, aquatic plants, and turbidity supported by monitoring data and technical reports

REACH 6. WATER QUALITY IMPACT SUMMARY (concluded)

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Ecosystem (Cold Water)			
Oily taste and mercury Temperature concerns	- Exceedance of objectives for ammonia, phenols and some metals in river, tributaries, and canals (Table 11) - Exceedance of objective for benthic algae in river (Table 18) - No exceedance of mercury objectives	- Low dissolved oxygen in May (36) - Low nighttime oxygen levels upstream of Policeman's Point created by weed growth in low flow years (24, 36) - Slight increase in total metals from tributary inflows however non-bioavailable (23) - Some detectable PAH's and PCP in fish tissue (3) - No problems with mercury in fish (30) - No temperature problems (24)	- No information on oily taste - No apparent problem with mercury or temperature
Agriculture			
Coliform bacteria and weed growth	- High macrophyte and algal growth upstream of Policeman's Point in low flow years (Table 17) - Phosphorus, coliform bacteria, and benthic algae objectives exceeded in river tributaries, and canals (Table 11)	- See comments for Reach 5	- Task Force concerns supported by monitoring data and technical reports
Industry			
Clogging of intakes with weeds	- Aquatic plant densities low to moderate (Table 17) - Algal densities exceed objective in low flow years (Table 18)	- See comments for Reach 5	- No excessive plant growth

REACH 7. WATER QUALITY IMPACT SUMMARY - BELOW CARSELAND WEIR TO BASSANO DAM (including Eastern Irrigation District).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
- Taste and odour, toxic metals, coliform bacteria, turbidity at Brooks and long-term effects	- Level III in river and canals primrily due to phosphorus and coliform bacteria (Table 12) - Manganese levels in Hussar drinking water exceed guidelines (Table 15) - All drinking water guidelines met at Arrowwood, Carseland, Rainier, Rolling Hills, Scandia, Kinbrook Island (Tables 15 and 16) - Ethylbenzene levels in Brooks drinking water exceeded guideline on 1 of 30 sampling occasions (Table 16)	- High storm related coliform bacteria at Bassano diversion (37) - Iron and manganese increase naturally along river (22)	- PAH's and PCP from Canada Creosote probably not detectable - No information to address Task Force concerns of taste and odour or long-term health effects - Toxic metals are not likely a problem - Turbidity in lake Newell and treated Brooks water is low and has not changed from 1986 to present
Recreation and Aesthetic Enjoyment			
- Weed growth (river and reservoirs), coliform bacteria and brown foam on water	- Contact recreation objectives exceeded for turbidity, pH, coliform bacteria and benthic algae in rivers and canals (Table 12) - Aesthetic objectives exceeded for benthic algae (rivers) and algae in reservoirs (Tables 12 and 18)	- River nutrient concentrations highest in spring and fall, but low in summer (14)	- No data on river aquatic plants or brown foam - Task Force concerns about bacteria supported by monitoring data

REACH 7 WATER QUALITY IMPACT SUMMARY (concluded).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Ecosystem (Cold Water) to Warm Water Transition)			
Weed growth and reluctance to eat fish Mercury	- Objectives exceeded for phenols, ammonia, some metals and benthic algae in rivers and canals (Tables 12, and 18)	- Dissolved oxygen is adequate at historic river flows, as long as plant biomass remains low (24) - Metals in river are generally non-bioavailable (23) - PCB and pesticide residues low in fish (19, 2) - No mercury problems in fish (30)	- No data on river aquatic plants - No apparent problems with eating fish
Agriculture			
Siltation of canals, coliform bacteria, weed growth, potential for increased salinity and rubber products in ditches	- Rare exceedances of conductivity and SAR in EID (Table 12) - Phosphorus, commonly exceeded in river and EID (Table 12) - Coliform bacteria and benthic algae exceeded in river (Tables 12, 18) - Stock watering objective for phosphorus exceeded (Table 12)	- High storm related coliform bacteria at Bassano diversion (37)	- No information to address Task Force concerns for canal siltation, weed growth, rubber products - Monitoring and technical information supports concerns for bacteria and salinity
Industry			
N/A	- N/A	- N/A	

REACH 8. WATER QUALITY IMPACT SUMMARY - BELOW BASSANO DAM TO OLDMAN RIVER.

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Municipal and Domestic Water Supply			
- Long-term health effects, toxic metals, coliform bacteria, turbidity	- Level III primarily due to turbidity, phosphorus and coliform bacteria (Table 13) - Manganese levels in Suffield drinking water exceed guidelines (Table 15)	- Trace levels of alpha-BHC, lindane and 2,4-D (28) - Most chlorobenzene isomers, nonionic pesticides, PCB and Mirex at or below detection limit (23) - Some irrigation drains not suitable as drinking water source due to high TDS (16)	- PAH's and PCP from Canada Creosote probably not detectable - Concerns for turbidity and bacteria supported by monitoring data - No apparent problem with toxic metals - No information on long-term health effects
Recreation and Aesthetic Enjoyment			
- Health risk concerns, brown foam on water, heavy weed growth in recent years and low water levels	- Objectives exceeded for turbidity, pH, coliform bacteria and algae (Table 13)	- Total coliform counts have been increasing over last ten years at Bow City (36)	- No data or technical reports on river aquatic plants or brown foam - Concern for bacteria supported by monitoring data and technical reports
Ecosystem (Warm Water)			
- Fish kill in 1979, tase and odour and fishing restricted by access	- Objectives are exceeded for pH, ammonia, phenols, some metals and benthic algae (Table 13)	- Metals associated with irrigation returnflow are largely unavailable, potential chronic low level leakage of metals from sediments in Bassano Reservoir (23)	- High phenols may lead to taste problems - No information on access

REACH 8. WATER QUALITY IMPACT SUMMARY (concluded).

TASK FORCE	MONITORING DATA REVIEW	TECHNICAL REPORT REVIEW	COMMENTS
Agriculture			
- Siltation, clogging of sprinklers by rubber products and weeds, low water levels	- Objectives exceeded for phosphorus, coliform bacteria and benthic algae (Table 13)	- Irrigation returnflow water has not had a significant impact on river salinity (16) - All irrigation drain salt levels suitable for livestock watering (16)	- No monitoring data or technical reports to address Task Force concerns
Industry			
- N/A	-	- N/A	

2.2 Task Force Information

The following pages list by reach and by water use all of the water quality problems members of the Task Force were aware of prior to review of monitoring data or technical reports. Water use in the Bow River Basin is summarized in Figure 1. The information included problems the members knew about and problems related to them by their member groups (both real and perceived problems). Potential sources for the problems were also identified.

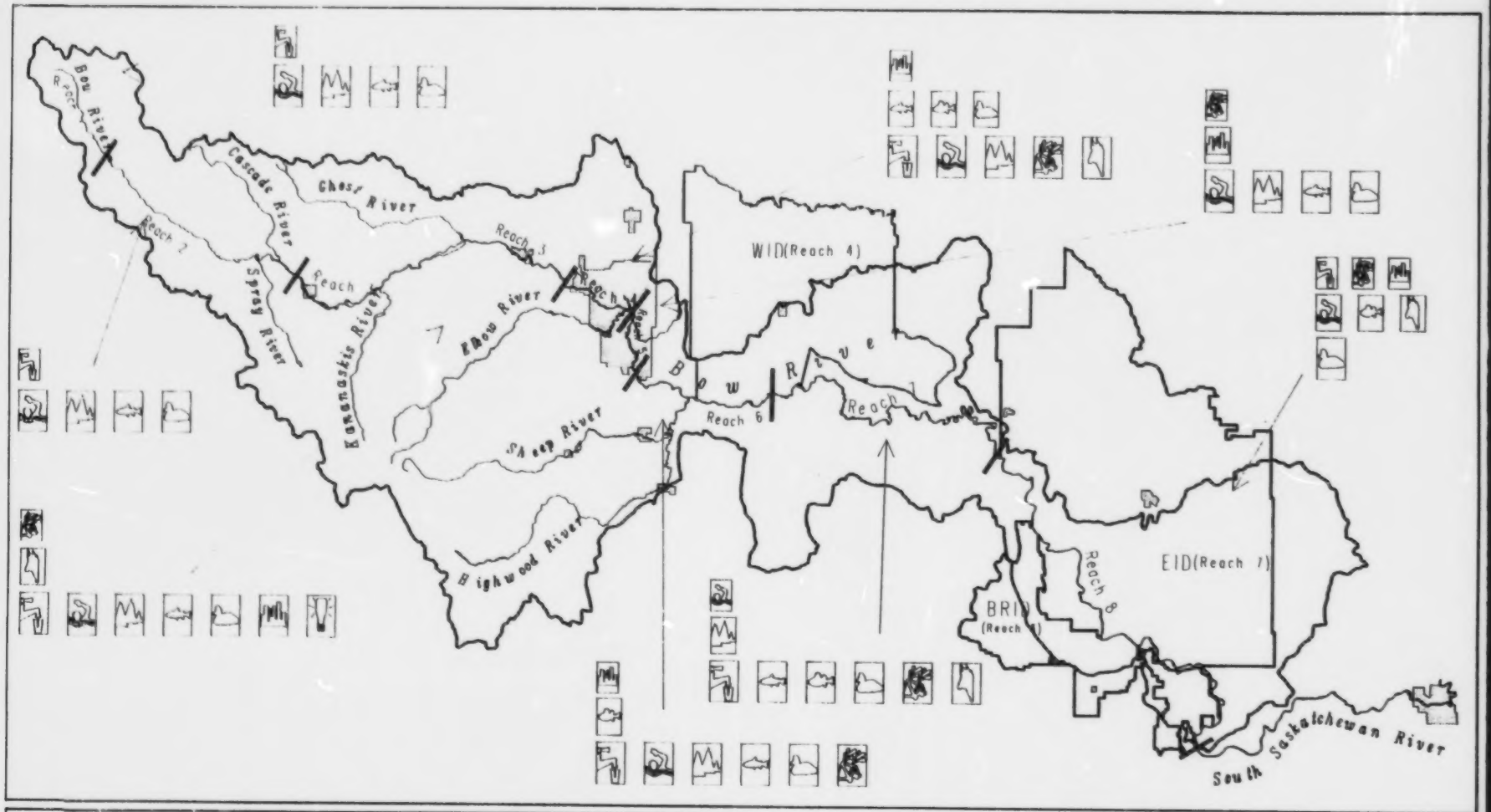


Figure 1

Water Use in the Bow River Basin

Produced by EWA
November 1991

Bow River
WATER QUALITY
TASK FORCE

REACH 1 HEADWATERS TO U/S LAKE LOUISE

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts?	Potential Cause of Impacts?
L	1. Municipal and Domestic Water Supply	- Throughout reach by recreational users	- *Giardia*	- Mammals
H	2. Recreation and Aesthetic Enjoyment a) Contact Recreation	- Throughout reach	- No problems at present - Potential - pathogens	- Sewage from lodges or resorts (direct or through leaky septic systems) - Spills from railroad bridges
H	b) Aesthetic Enjoyment	- Throughout reach	- No problems at present	- Any modification to river bank would be of concern
H	3. Ecosystem a) Cold Water	- Throughout reach	- No problems at present	
N/A	b) Warm Water			
H	c) Wildlife	- Throughout reach	- No problems at present	
N/A	4. Agriculture a) Irrigation			
N/A	b) Stock Watering			
N/A	5. Water Disposal			
N/A	6. Industry			
N/A	7. Hydro-Power			

N/A - Not Applicable, H - High, M - Medium, L - Low

REACH 2 LAKE LOUISE TO BANFF PARK BOUNDARY (including Spray River)

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts?	Potential Cause of Impacts?
L	1 Municipal and Domestic Water Supply	- Possibly upstream Banff by recreational users	- *Giardia* - Salts (perceived)	- Mammals - Runoff from ski hill parking lots
H	2. Recreation and Aesthetic Enjoyment a) Contact Recreation	- Throughout reach	- Health risks - Coliform bacteria	- Sewage effluent
H	b) Aesthetic Enjoyment	- Throughout reach	- Algal growth in river	- Sewage effluent
H	3. Ecosystem a) Cold Water	- Throughout reach	- Toxins (potential) - Algal growth	- Highway runoff (road salt) and railroad spills - Sunshine Village sewage (Healy Creek)
N/A	b) Warm Water			
H	c) Wildlife	- Throughout reach	- No problems at present	
N/A	4 Agriculture a) Irrigation			
N/A	b) Stock Watering			
N/A	5 Water Disposal			
N/A	6 Industry			
N/A	7 Hydro-Power			

N/A Not Applicable, H - High, M - Medium, L - Low

REACH 3 BANFF PARK TO BEARSPAW DAM (including Ghost River, Spray Lakes and Kananaskis River)

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts?	Potential Cause of Impacts?
H	1. Municipal and Domestic Water Supply	- Canmore, Cochrane, Artists View, Native Reserves	- Bacteria at Bearspaw Plant and Cochrane - Taste and odour and organic contaminants at Cochrane - Real and perceived problems	- Gas plant on Jumping Pound Creek - Contaminated industrial site on Big Hill Creek - Golf courses in Canmore Corridor - Banff sewage effluent impact on Canmore - Canmore impact on Calgary (lift station flooding) - Cochrane impact on Calgary
H	2. Recreation and Aesthetic Enjoyment a) Contact Recreation	- Throughout reach - Ghost Reservoir and Lac des Arcs	- Turbidity in Ghost Reservoir - Coliforms at Cochrane	- Low flows - Upstream sewage discharges - Naturally high turbidity - Golf course runoff and sewage
H	b) Aesthetic Enjoyment	- All along river	- Dust at Lac des Arcs - Trash on banks	- Sedimentation
H	3. Ecosystem a) Cold Water	- Throughout reach		- Golf course runoff and sewage
N/A	b) Warm Water	N/A	N/A	N/A
H	c) Wildlife	- Throughout reach		- Golf course runoff and sewage
L	4. Agriculture a) Irrigation	- Golf course irrigation		- Suspected impacts from golf courses
M	b) Stock Watering	- All along reach		
M	5. Water Disposal	- Banff, Canmore, Cochrane		- Suspected coal mine wastes at Canmore - Potential impact on Calgary water supply
H	6. Industry	- Gas plants at Cochrane and Exshaw	- Siltation of intakes	
H	7. Hydro-Power			

N/A - Not Applicable, H - High, M - Medium, L - Low

REACH 4: BELOW BEARSPAW DAM TO WID WEIR (including Elbow River, Nose Creek, Western Irrigation District and Chestermere Lake)

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts	Potential Causes of Impacts?
H	1. Municipal and Domestic Water Supply	- Intake for Bearspaw water treatment plant - Domestic and municipal use in WID	- Risk of health effects	- Abandoned land fill near Nose Creek - Urban development and drainage - Contaminated industrial sites - Railway lines, Alyth Yard - Chemical spills - Golf courses on Elbow River
M	2. Recreation and Aesthetic Enjoyment a) Contact Recreation	- Chestermere Lake - Throughout reach	- Coliforms, weeds, algae, debris in Chestermere Lake - Weed problem is low in river but high in canals - Debris and to a lesser extent algae in river	- Low river flows and lake levels - Urban runoff - Salts and Silts from snow dumps
H	b) Aesthetic Enjoyment	- Throughout reach		- Trash
M	3. Ecosystem a) Cold Water	- Throughout reach	- Potential fish tainting (esp. suckers)	- Abandoned land fill on Nose Creek - Canada Creosote site and other industrial sites - Urban runoff
M	b) Warm Water	- Chestermere Lake, irrigation canals		
M	c) Wildlife	- Throughout reach		
H	4. Agriculture a) Irrigation	- High use by WID	- High silt deposition in canals during runoff - Weeds in Chestermere Lake and canal silting	- Nose Creek runoff - Urban runoff (snow melt) - Agricultural runoff - Wind and water erosion
H	b) Stock Watering	- Just below Bearspaw and WID		
H	5. Water Disposal	- Urban runoff		
L	6. Industry	- University cooling water - Some use in WID		- Potential thermal pollution
N/A	7. Hydro-Power			- Flow variation can cause ice dams

N/A - Not Applicable, H - High, M - Medium, L - Low

REACH 5 BELOW WID WEIR TO HWY 22

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts?	Potential Cause of Impacts?
N/A	1. Municipal and Domestic Water Supply	- No use here but concern for downstream users	- Organic contaminants	- Abandoned industrial sites and risk of hazardous spills from trains and trucks - Urban runoff
H	2. Recreation and Aesthetic Enjoyment a) Contact Recreation	- All along reach, fishing, boating, wading, Sikome Lake	- Bacterial pollution - Weed growth - Oily smell	- Calgary sewage - Urban runoff
H	b) Aesthetic Enjoyment	- Walking, birding, biking	- Weed growth problem - Oily smell	- Trash
H	3. Ecosystem a) Cold Water	- All along reach, including brown trout spawning	- Fish kills - Fish taste and contamination suspected	- Fish trapped under ice - Low oxygen in weed beds - Sewage plants - Cominco wastewater - Urban runoff - Old industrial sites, i.e. refineries
N/A	b) Warm Water	N/A	N/A	N/A
H	c) Wildlife	- Heavy use by birds, deer (Inglewood Sanctuary)	- Winter bird kills	
L	4. Agriculture a) Irrigation	- Golf course irrigation	- Drying up of Fish Creek	
N/A	b) Stock Watering			
H	5. Water Disposal	- Calgary sewage plants, urban runoff, industrial	- No limitations with respect to disposal under existing regulations	- Runoff from golf courses - Bacterial loadings are a concern - Concern for more stringent standards
M	6. Industry	- canals	- Weeds and floating garbage - High conductivity	- Low flows cause weed growth - Urban runoff (snow melt, road salts)
N/A	7. Hydro-Power			

N/A - Not Applicable; H - High; M - Medium; L - Low

REACH 6 - HWY 22 TO CARSELAND WEIR (including Sheep and Highwood Rivers and Bow River Irrigation District

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts?	Potential Cause of Impacts?
H	1. Municipal and Domestic Water Supply (Potential 20,000 People in BRID)	- Throughout reach	- Toxic metals - Coliform bacteria - Health effects	- Calgary sewage
H	2. Recreation and Aesthetic Enjoyment a) Contact Recreation	- Throughout reach	- Swimmer's itch - Bacteria - Weeds	- Low flows (affect weed growth) - Calgary sewage - Feedlot runoff - Storm sewers
H	b) Aesthetic Enjoyment	- Throughout reach	- Bank erosion - Weeds - Turbidity	- Floating debris - Cattle access
H	3. Ecosystem a) Cold Water	- River	- Oily taste - Mercury - Temperature problems	- Industries - Calgary runoff
M	b) Warm Water	- Canals		
H	c) Wildlife		- Potentially vulnerable	
H	4. Agriculture a) Irrigation	- River and canals	- Coliform bacteria (vegetables) - Weed growth	- Calgary sewage - Intensive livestock operations
	b) Stock Watering			
H	5. Water Disposal			- Calgary sewage and runoff
L	6. Industry	- Near Carseland	- Clogging of intakes with weeds	- Calgary sewage - Intensive livestock operations
N/A	7. Hydro-Power			

N/A - Not Applicable, H - High, M - Medium, L - Low

REACH 7. BELOW CARSELAND WEIR TO BASSANO DAM (including Eastern Irrigation District)

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts?	Potential Cause of Impacts?
H	1. Municipal and Domestic Water Supply (Potential 30,000 People, including EID)	- Throughout reach	- Taste and odour - Toxic metals - Coliform bacteria (storm runoff) - Turbidity at Brooks - Long term health effects (e.g. Chrons disease)	- Calgary sewage - Calgary urban runoff - Septic tank leakage to Lake Newell
L	2. Recreation and Aesthetic Enjoyment a) Contact Recreation	- Throughout reach	- Brown foam on water - Weed growth (river and reservoirs) - Coliform bacteria (river)	- Top soil drifting - Sewage from small municipalities - Natural growth of weeds along canals - Calgary sewage - Low flows aggravate weed growth
M	b) Aesthetic Enjoyment	- Throughout reach	- Weed growth (river) - Brown foam on water	- Calgary sewage - Low flows aggravate weed growth
H	3. Ecosystem a) Cold Water (d/s Carseland)	- Below Carseland	- Reluctance of people to eat fish - Weed growth - Concern for mercury contamination	
H	b) Warm Water	- Lower parts of reach	- No existing problem but high risk to economy	
H	c) Wildlife			
H	4. Agriculture a) Irrigation	- Rivers and canals	- Siltation of canals - Potential for salt - Coliform bacteria - Rubber products in ditches - Weed growth	- Low river flows - Natural siltation of canals - Nutrients from agricultural land and intensive livestock operations - Sewage from Calgary and other municipalities - Calgary urban runoff
H	b) Stock Watering	- Within EID	- Yoxic blue-green algae in dugouts (rare)	- Sewage and feedlot runoff from WID returnflows
	5. Water Disposal			
N/A	6. Industry			
N/A	7. Hydro-Power			

N/A - Not Applicable, H - High, M - Medium, L - Low

REACH 8 BELOW BASSANO DAM TO OLDMAN RIVER

Extent of Existing Use (H,M,L)	Use	Where Does Use Occur?	POLLUTION PROBLEMS	
			What Kind of Impacts?	Potential Cause of Impacts?
L	1 Municipal and Domestic Water Supply (Domestic Only)	· Throughout reach	· Long-term health effects? · Toxic metals · Coliform bacteria · Turbidity	· Abandoned industrial sites · Irrigation returnflow · Coal mining and gravel pits · City of Calgary sewage · Calgary runoff · Intensive livestock operations
L-M	2 Recreation and Aesthetic Enjoyment a) Contact Recreation	· Throughout reach	· Brown foam on water · Health risk concerns · Weed growth is heavy in recent years · Low water levels (poor access)	· Bank destruction by stock access · Calgary sewage · Low river flows · Vegetable washing · Diversion to EID
	b) Aesthetic Enjoyment	· Throughout reach	· Weed growth · Low water levels (poor access)	· Bank destruction by stock access
N/A	3 Ecosystem a) Cold Water	---	---	---
M	b) Warm Water		· Fish kill in 1979 · Taste and odour · Fishing restricted by access	· Livestock wastes · Bank trampling by livestock (nutrients)
H	c) Wildlife		· No problems	
L	4 Agriculture a) Irrigation (private)	· Throughout reach	· Siltation · Clogging of sprinklers by rubber products · Weeds clog intakes · Low water levels	· Rubber products may be from sewage but likely not Calgary; could indicate sewage dumping
M	b) Stock Watering		· No problem	
H	5 Water Disposal (returnflows)			· Potential source of sewage and feedlot runoff
L	6 Industry			
N/A	7 Hydro-Power			

N/A - Not applicable, H - High, M - Medium, L - Low

2.3 Monitoring Data Review

Goals for Water Quality Monitoring

There are a number of reasons for monitoring water quality:

- assessment of temporal trends that may result from human activities (e.g., implementation of phosphorus-reduction measures by City of Calgary's sewage treatment plants) or natural factors (e.g., changes in climatic conditions)
- compliance with water quality objectives, e.g., to determine whether or not objectives set for quality are being met
- estimating the amount of material that is being carried in a river (i.e., mass transport) to determine amounts of a pollutant, effect of a particular control measure, effect of land-use practices, compliance with objectives and to provide the necessary information to model water quality
- assessment of environmental impact or effect from a particular activity or problem, e.g., impact of storm sewer runoff on fecal coliform levels
- general surveillance to determine general levels of water quality over a broad spatial area and to provide an early warning of emerging problems

Types of Water Quality Monitoring Programs

A single water quality monitoring program cannot achieve every goal with one data collection procedure. Rather, different types of monitoring programs are employed to address specific goals.

Long-term monitoring stations

- samples are collected over long periods of time at fixed intervals (e.g., monthly) at a single site
- primarily used to assess seasonal and long-term trends in water quality and secondarily for compliance monitoring, estimation of mass transport, and assessment of environmental impact
- five stations on Bow River (Lake Louise, Canmore, Cochrane, Carseland, Ronlane Bridge)

Synoptic surveys

- samples are collected within a short time interval at a number of different sites
- primarily for general surveillance but also provides information on compliance with objectives, mass transport, and environmental impacts

Special monitoring programs

- variable sampling design to provide information on specific aspects of water quality
- tend to be short-term programs to identify environmental impacts (e.g., Canada Creosote, golf-course runoff study)

Types of Water Quality Data

Water quality monitoring programs have traditionally focused on physical, chemical, and biological variables found in the water column:

Physical

- water temperature, turbidity, colour

Chemical

- major ions and associated variables (e.g., sodium, pH, TDS)
- nutrients (e.g., phosphorus, nitrogen)
- suspended solids
- dissolved oxygen
- metals and trace elements (e.g., aluminum, arsenic, lead)
- organic matter (e.g., DOC, phenolic compounds, tannin and lignin)

Biological

- coliform bacteria (fecals and totals)
- algae (benthic and planktonic)

These variables are relatively inexpensive to measure (e.g., $150 per sample) and their roles in river or lake ecosystems are fairly well understood. These are the variables most often analyzed from samples collected at long-term monitoring stations and during synoptic surveys.

As analytical methods have improved, some of the emphasis of monitoring programs, especially those designed to assess environmental impacts, has shifted towards trace organic compounds (e.g., PCB's, dioxins, PAH's, pesticides). Most of these compounds are man-made and some are extremely toxic to aquatic biota and may present human health concerns. However, laboratory analysis of these compounds is difficult, very expensive (e.g., $2000 per sample), and their effects on aquatic ecosystems and human health are, in general, poorly understood. An extensive trace organic contaminant data set has been collected as part of the Canada Creosote monitoring program.

Another recent development in water quality monitoring programs is the sampling of media in addition to water. Nutrients, heavy metals, and some trace organic contaminants readily "attach" to particulate material, which may in turn settle out to the bottom of a river or lake. Contaminants associated with the settled particulate matter may then enter the aquatic food chain as small bottom-dwelling invertebrates feed upon the detritus and in turn are fed upon by larger invertebrates and fish. In addition, some plants may selectively take up contaminants through their root system. Invertebrates that feed on the plants may then incorporate the contaminants into their tissues. Therefore, in addition to collecting water samples, some recent monitoring programs have included sampling of bottom sediments, plants, invertebrates, and fish for analysis of chemical residues. The most notable "multi-media" study on the Bow River was for the evaluation of environmental impacts from Canada Creosote.

2.3.1. Overview of Existing Monitoring Programs

Water quality data from the Bow River Basin are available from a number of different sources. In summary, EQMB has three ongoing programs:

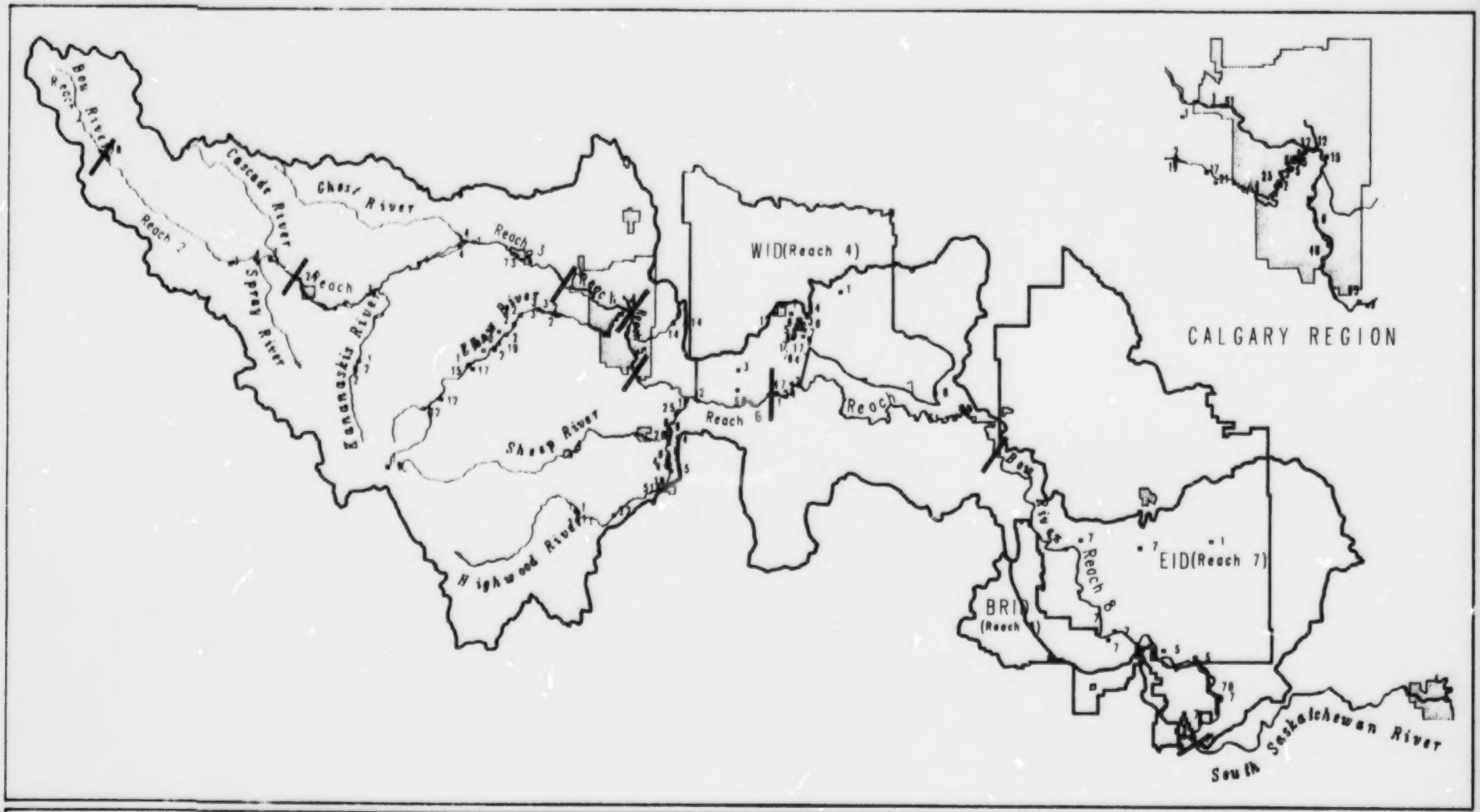
- long-term monitoring network of three sites (Cochrane, Carseland, and Ronlane Bridge) that are sampled monthly
- program to monitor the effect of phosphorus removal at Calgary's sewage treatment plants
- evaluation of the effects of Canada Creosote.

Since 1985, a total of 129 different sites have been sampled by EQMB; each site has been sampled from 1 to 93 times (Figure 2). Twenty-one of the 129 sites were located on the Bow River, 85 on tributaries to the Bow River, 14 in irrigation canals, and five in reservoirs and lakes. Water quality data from these sampling programs are stored in a computer database (NAQUADAT).

In addition to EQMB, Municipal Branch, Alberta Environment collects surface water samples from the Bow River Basin. These samples are collected as part of a program to monitor raw and treated water for drinking water supplies. These data are stored in NAQUADAT.

Environment Canada maintains two long-term monitoring stations on the Bow River upstream of Lake Louise and Canmore. These data are stored in a computer database (NAQUADAT) maintained by Environment Canada. In conjunction with the Banff Warden Service, Environment Canada also monitors bacteria in surface water in Banff National Park.

In addition to the programs listed above, water quality data have been collected by municipalities, irrigation districts, universities and other research institutes, and industries. These data are generally incorporated into technical reports.



Legend

- Sampling sites

Note: Number corresponds to total number of sampling occasions

Figure 2

Sampling Sites (1985-1990)

Produced by EMA
November 1991

Bow River
WATER QUALITY
TASK FORCE

2.3.2 Evaluation of Surface Water Quality

The evaluation of surface water quality focused on data collected by Alberta Environment and Environment Canada that are stored in NAQUADAT. These data include the majority of sites and samples collected in the Bow River Basin over the last six years (since 1985). Surface water quality was evaluated by comparing the maximum concentration for each variable at each site to the use-specific water quality objectives developed previously. Results of this compliance evaluation are summarized in Tables 6 to 13 and Figures 3 to 9.

Table 6. Reach 1 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

Variable	Drinking Water			Contact Recreation	Aesthetic Enjoyment	Ecosystem		Agricultural		Industry (1)
	Level I	Level II	Level III			Cold Water	Warm Water (1)	Irrigation (1)	Livestock (1)	
TDS	--	--	--							
Colour	--	--	--							
Conductivity										
SAR										
Temperature						--				
Turbidity	--	--	--	--						
Secchi Depth				--						
Dissolved Oxygen						0/1				
pH	1/1	0/1	N/A	0/1		0/1				
Phenols						--				
Nitrate	1/1	1/1	0/1							
Ammonia						--				
Total Phosphorus	1/1	0/1	0/1	0/1	0/1					
Chloride	--	--	--							
Fluoride	1/1	1/1	0/1							
Sodium	1/1	1/1	0/1							
Sulphate	1/1	1/1	0/1							
Aluminum										
Arsenic	--	--	--			--				
Barium	--	--	--			--				
Boron	1/1	0/1	N/A							
Cadmium	--	--	--							
Chromium	--	--	--			--				
Cobalt						--				
Copper	--	--	--							
Iron	1/1	0/1	N/A			0/1				
Lead	--	--	--			--				
Manganese	1/1	0/1	N/A							
Mercury	1/1	0/1	N/A			0/1				
Nickel						--				
Selenium	1/1	0/1	N/A							
Zinc	--	--	--			--				
2,4-D						--				
Trace Organics	--	--	--							
Total Coliforms	1/1	0/1	0/1	0/1						
Fecal Coliforms	1/1	0/1	0/1	0/1						
Planktonic Algae	--	--	--	--	--					
Benthic Algae				--	--	--				

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

Table 7. Reach 2 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

April 24/1991

Variable	Drinking Water			Contact Recreation	Aesthetic Enjoyment	Ecosystem		Agricultural		Industry (1)
	Level I	Level II	Level III			Cold Water	Warm Water (1)	Irrigation (1)	Livestock (1)	
TDS	--	--	--							
Colour	--	--	--							
Conductivity										
SAR										
Temperature										
Turbidity	--	--	--	--		--				
Secchi Depth				--						
Dissolved Oxygen										
pH	1/1	0/1	N/A	0/1		0/1				
Phenols						0/1				
Nitrate	4/4	4/4	0/4			--				
Ammonia										
Total Phosphorus	1/4	4/4	0/4	--	--	0/1				
Chloride	2/2	2/2	0/2							
Fluoride	1/1	1/1	0/1							
Sodium	1/1	1/1	0/1							
Sulphate	1/1	1/1	0/1							
Aluminum										
Arsenic						--				
Barium	--	--	--			--				
Boron	--	--	--							
Cadmium	--	--	--							
Chromium	--	--	--			--				
Cobalt						--				
Copper	--	--	--							
Iron	2/2	0/2	N/A			--				
Lead	--	--	--			0/2				
Manganese	1/1	0/1	N/A			--				
Mercury	2/2	0/2	N/A							
Nickel						0/2				
Selenium	1/1	0/1	N/A			--				
Zinc	--	--	--							
2,4-D						--				
Trace Organics	--	--	--			--				
Total Coliforms	1/1	0/1	0/1	0/1						
Fecal Coliforms	1/1	0/1	0/1	0/1						
Planktonic Algae	--	--	--	--	--					
Benthic Algae				--	--	--				

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

Table 8. Reach 3 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

Variable	Drinking Water			Contact	Aesthetic	Ecosystem		Agricultural		Industry
	Level I	Level II	Level III	Recreation	Enjoyment	Cold Water	Warm Water (1)	Irrigation	Livestock	
TDS	4/4	4/4	0/4					0/4	0/4	
Colour	--	--	--							
Conductivity								0/4		
SAR								--		
Temperature						0/1				
Turbidity	2/3	1/3	N/A	0/3						
Secchi Depth				0/1						
Dissolved Oxygen						0/3				
pH	3/3	0/3	N/A	0/3		0/3				
Phenols						0/3				
Nitrate	6/6	6/6	N/A						0/6	
Ammonia						0/5				
Total Phosphorus	2/5	4/5	1/5	0/1	0/1			3/5	0/5	
Chloride	5/5	5/5	0/5							
Fluoride	3/3	3/3	0/3					0/3	0/3	
Sodium	6/6	6/6	0/6							
Sulphate	6/6	6/6	0/6						0/6	
Aluminum						0/1		0/6	0/6	
Arsenic	1/1	0/1	N/A			0/1		0/1	0/1	
Barium	1/1	0/1	N/A							
Boron	2/2	0/2	N/A					0/2	0/2	
Cadmium	0/1	0/1	N/A			0/1		0/1	0/1	
Chromium	1/1	0/1	N/A			0/1		0/1	0/1	
Cobalt								0/1	0/1	
Copper	1/1	0/1	N/A			0/1		0/1	0/1	
Iron	5/5	0/5	N/A			0/5		0/5		
Lead	--	--	--			--		--	--	
Manganese	2/2	0/2	N/A					0/2		
Mercury	7/7	0/7	N/A			0/7			0/7	
Nickel						0/1		0/1	0/1	
Selenium	2/2	0/2	N/A					0/2	0/2	
Zinc	1/1	0/1	N/A			0/1		0/1	0/1	
2,4-D						0/2		0/2		
Trace Organics	1/1	1/1	0/1							
Total Coliforms	0/2	1/2	1/2	1/2				1/2		
Fecal Coliforms	0/2	1/2	1/2	1/2				1/2		
Planktonic Algae	0/1	1/1	0/1	0/1	0/1					
Benthic Algae				--	--	--		--		--

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

Table 9. Reach 4 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

Variable	Drinking Water			Contact Recreation	Aesthetic Enjoyment	Ecosystem		Agricultural		Industry
	Level I	Level II	Level III			Cold Water	Warm Water	Irrigation	Livestock	
TDS	21/23	21/23	2/23							
Colour	12/16	4/6	0/16					1/23	0/23	
Conductivity										
SAR								2/24		
Temperature								0/6		
Turbidity	7/22	15/22	N/A			0/23	0/23			
Secchi Depth				8/22						
Dissolved Oxygen				1/2						
pH	21/23	2/23	N/A	2/23		2/23	0/23			
Phenols						0/23	0/23			
Nitrate	38/38	38/38	0/38			20/22	20/22			
Ammonia									0/38	
Total Phosphorus	10/60	13/60	37/60	2/4	2/4	3/25	5/25			
Chloride	22/23	22/23	1/23					48/60	32/56	
Fluoride	21/21	21/21	0/21							
Sodium	24/30	24/30	6/30					0/21	0/21	
Sulphate	23/23	23/23	0/23							
Aluminum									0/23	
Arsenic	4/4	0/4	N/A			1/2	1/2	0/2	0/2	
Barium	15/15	0/15	N/A			0/4	0/4	0/4	0/4	
Boron	15/15	0/15	N/A							
Cadmium	18/18	0/18	N/A					0/15	0/15	
Chromium	18/18	0/18	N/A			1/18	1/18	0/18	0/18	
Cobalt						6/18	6/18	0/18	0/18	
Copper	18/18	0/18	N/A					0/14	0/14	
Iron	17/21	4/21	N/A			2/18	2/18	0/18	0/18	
Lead	17/18	1/18	N/A			4/21	4/21	0/21		
Manganese	2/3	1/3	N/A			5/18	5/18	0/18	0/18	
Mercury	19/19	0/19	N/A					0/3		
Nickel						0/19	0/19		0/19	
Selenium	1/1	0/1	N/A			0/6	0/6	0/6	0/6	
Zinc	18/18	0/18	N/A					0/1	0/1	
2,4-D						1/18	1/18	0/18	0/18	
Trace Organics	0/1	1/1	1/1			0/1	0/1	0/1		
Total Coliforms	4/22	14/22	4/22	4/22						
Fecal Coliforms	3/22	11/22	8/22	6/22				4/22		
Planktonic Algae	0/5	3/5	2/5	2/5	2/5			6/22		
Benthic Algae				6/8	4/8	4/8	4/8	4/8		4/8

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

Table 10. Reach 5 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

Variable	Drinking Water			Contact Recreation	Aesthetic Enjoyment	Ecosystem		Agricultural		Industry
	Level I	Level II	Level III			Cold Water	Warm Water (1)	Irrigation	Livestock	
TDS	0/1	0/1	0/1					0/1	0/1	
Colour	--	--	--							
Conductivity								0/1		
SAR								--		
Temperature						1/2				
Turbidity	0/1	1/1	0/1	0/1						
Secchi Depth				--						
Dissolved Oxygen						0/2				
pH	1/2	1/2	N/A	1/2		0/2				
Phenols						--				
Nitrate	3/3	3/3	0/3						0/3	
Ammonia						0/3				
Total Phosphorus	0/1	0/1	1/1	--	--			1/1	0/1	
Chloride	1/1	1/1	0/1							
Fluoride	--	--	--					--	--	
Sodium	1/1	1/1	0/1							
Sulphate	1/1	1/1	0/1						0/1	
Aluminum						0/1		0/1	0/1	
Arsenic	1/1	0/1	N/A			0/1		0/1	0/1	
Barium	--	--	--							
Boron	--	--	--					--	--	
Cadmium	1/1	0/1	N/A			0/1		0/1	0/1	
Chromium	1/1	0/1	N/A			0/1		0/1	0/1	
Cobalt								--	--	
Copper	1/1	0/1	N/A			0/1		0/1	0/1	
Iron	1/1	0/1	N/A			0/1		0/1		
Lead	1/1	0/1	N/A			1/1		0/1	0/1	
Manganese	1/1	0/1	N/A					0/1		
Mercury	1/1	0/1	N/A			0/1			0/1	
Nickel						--		--	--	
Selenium	--	--	--					--	--	
Zinc	1/1	0/1	N/A			0/1		0/1	0/1	
2,4-D						--		--		
Trace Organics	--	--	--							
Total Coliforms	0/1	0/1	1/1	1/1				1/1		
Fecal Coliforms	0/1	0/1	1/1	1/1				1/1		
Planktonic Algae	0/1	1/1	0/1	--	--					
Benthic Algae				--	--	--		--		--

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

Table 11. Reach 6 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

Variable	Drinking Water			Contact Recreation	Aesthetic Enjoyment	Ecosystem		Agricultural		Industry
	Level I	Level II	Level III			Cold Water	Warm Water	Irrigation	Livestock	
TDS	15/16	15/16	1/16							
Colour	6/6	0/6	0/6					1/16	0/16	
Conductivity										
SAR								1/17		
Temperature								0/16		
Turbidity	1/15	11/15	3/15	3/15		4/33	0/33			
Secchi Depth				--						
Dissolved Oxygen										
pH	19/30	11/30	N/A	6/30		0/26	0/26			
Phenols						0/30	0/30			
Nitrate	27/27	27/27	0/27			14/15	14/15			
Ammonia									0/27	
Total Phosphorus	3/27	6/27	19/27	--	--	12/24	18/24			
Chloride	16/16	16/16	0/16					23/27	15/27	
Fluoride	8/8	8/8	0/8							
Sodium	16/16	16/16	0/16					0/8	0/8	
Sulphate	16/16	16/16	0/16							
Aluminum									0/16	
Arsenic	4/4	0/4	N/A			--	--	--	--	
Barium	--	--	--			0/4	0/4	0/4	0/4	
Boron	4/4	0/4	N/A							
Cadmium	4/4	0/4	N/A					0/4	0/4	
Chromium	4/4	0/4	N/A			0/4	0/4	0/4	0/4	
Cobalt						1/4	1/4	0/4	0/4	
Copper	4/4	0/4	N/A					0/1	0/1	
Iron	10/15	5/15	N/A			1/4	1/4	0/4	0/4	
Lead	4/4	0/4	N/A			5/15	5/15	0/15		
Manganese	4/4	0/4	N/A			1/4	1/4	0/4	0/4	
Mercury	5/5	0/5	N/A					0/4		
Nickel						0/5	0/5		0/5	
Selenium	1/1	0/1	N/A			0/4	0/4	0/4	0/4	
Zinc	4/4	0/4	N/A					0/1	0/1	
2,4-D						0/4	0/4	0/4	0/4	
Trace Organics	0/1	0/1	1/1			0/1	0/1	0/1		
Total Coliforms	9/19	5/19	5/19	5/19						
Fecal Coliforms	13/25	5/25	7/25	5/25				5/19		
Planktonic Algae	2/9	5/9	2/9	--				5/25		
Benthic Algae				8/8	7/8	7/8	7/8	7/8		7/8

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

Table 12. Reach 7 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

Variable	Drinking Water			Contact	Aesthetic	Ecosystem		Agricultural		Industry
	Level I	Level II	Level III	Recreation	Enjoyment	Cold Water	Warm Water	Irrigation	Livestock	
TDS	7/7	7/7	0/7					0/7	0/7	
Colour	0/1	1/1	0/1							
Conductivity								1/7		
SAR								1/8		
Temperature						1/5	0/5			
Turbidity	1/6	5/6	N/A	2/6						
Secchi Depth				0/2						
Dissolved Oxygen						0/6	0/6			
pH	4/6	2/6	N/A	2/6		0/6	0/6			
Phenols						5/5	5/5			
Nitrate	8/8	8/8	N/A						0/8	
Ammonia						3/7	3/7			
Total Phosphorus	0/9	5/9	4/9	0/2	0/2			8/9	4/9	
Chloride	8/8	8/8	0/8							
Fluoride	4/4	4/4	0/4					0/4	0/4	
Sodium	7/8	7/8	1/8							
Sulphate	8/8	8/8	0/8						0/8	
Aluminum						1/1	1/1	0/1	0/1	
Arsenic	2/2	0/2	N/A			0/2	0/2	0/2	0/2	
Barium	1/1	0/1	N/A							
Boron	2/2	0/2	N/A					0/2	0/2	
Cadmium	2/2	0/2	N/A			0/2	0/2	0/2	0/2	
Chromium	2/2	0/2	N/A			1/2	1/2	0/2	0/2	
Cobalt								0/1	0/1	
Copper	2/2	0/2	N/A			1/2	1/2	0/2	0/2	
Iron	4/7	3/7	N/A			3/7	3/7	0/7		
Lead	2/2	0/2	N/A			1/2	1/2	0/2	0/2	
Manganese	1/2	1/2	N/A					0/2		
Mercury	3/3	0/3	N/A			0/3	0/3		0/3	
Nickel						0/2	0/2	0/2	0/2	
Selenium	2/2	0/2	N/A					0/2	0/2	
Zinc	2/2	0/2	N/A			0/2	0/2	0/2	0/2	
2,4-D						0/1	0/1	0/1		
Trace Organics	--	--	--							
Total Coliforms	0/2	0/2	2/2	2/2				2/2		
Fecal Coliforms	0/2	0/2	2/2	2/2				2/2		
Planktonic Algae	0/3	2/3	1/3	0/2	1/2					
Benthic Algae				1/1	1/1	1/1	1/1	1/1		1/1

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

Table 13. Reach 8 Compliance Summary - 1985-1990 NAQUADAT data. For drinking water the values given are the number of sites that meet the guideline over the total number of sites sampled; for other uses the values are the number of sites that do not comply with the guideline over the total number of sites.

Variable	Drinking Water			Contact Recreation	Aesthetic Enjoyment	Ecosystem		Agricultural		Industry
	Level I	Level II	Level III			Cold Water (1)	Warm Water	Irrigation	Livestock	
TDS	3/3	3/3	0/3							
Colour	--	--	--					0/3	0/3	
Conductivity								0/3		
SAR								0/4		
Temperature										
Turbidity	0/3	3/3	N/A	3/3			0/3			
Secchi Depth				--						
Dissolved Oxygen							0/4			
pH	0/4	4/4	N/A	4/4			2/4			
Phenols							3/3			
Nitrate	4/4	4/4	N/A						0/4	
Ammonia							4/4			
Total Phosphorus	0/4	0/4	4/4	--	--			4/4	4/4	
Chloride	4/4	4/4	0/4							
Fluoride	2/2	2/2	0/2					2/2	2/2	
Sodium	4/4	4/4	0/4							
Sulphate	4/4	4/4	0/4						0/4	
Aluminum							0/1	0/1	0/1	
Arsenic	4/4	0/4	N/A				0/4	0/4	0/4	
Barium	1/1	0/1	N/A							
Boron	4/4	4/4	N/A					0/4	0/4	
Cadmium	--	--	N/A				0/4	0/4	0/4	
Chromium	4/4	0/4	N/A				2/4	0/4	0/4	
Cobalt								0/2	0/2	
Copper	4/4	0/4	N/A				3/4	0/4	0/4	
Iron	2/4	2/4	N/A				2/4	0/4		
Lead	4/4	0/4	N/A				2/4	0/4	0/4	
Manganese	4/4	0/4	N/A					0/4		
Mercury	4/4	0/4	N/A				0/4		0/4	
Nickel							0/4	0/4	0/4	
Selenium	2/2	0/2	N/A					0/2	0/2	
Zinc	4/4	0/4	N/A				2/4	0/4	0/4	
2,4-D							0/1	0/1		
Trace Organics	0/1	0/1	1/1							
Total Coliforms	0/4	1/4	3/4	3/4				3/4		
Fecal Coliforms	0/4	0/4	4/4	3/4				3/4		
Planktonic Algae	0/3	3/3	0/3							
Benthic Algae				3/3	3/3		3/3	3/3		3/3

NOTE: Blanks indicate that no objectives exist for that variable and water use, and "--" indicates that data were not available to test objectives.
(1) Not evaluated as that water use is not applicable to this reach of river.

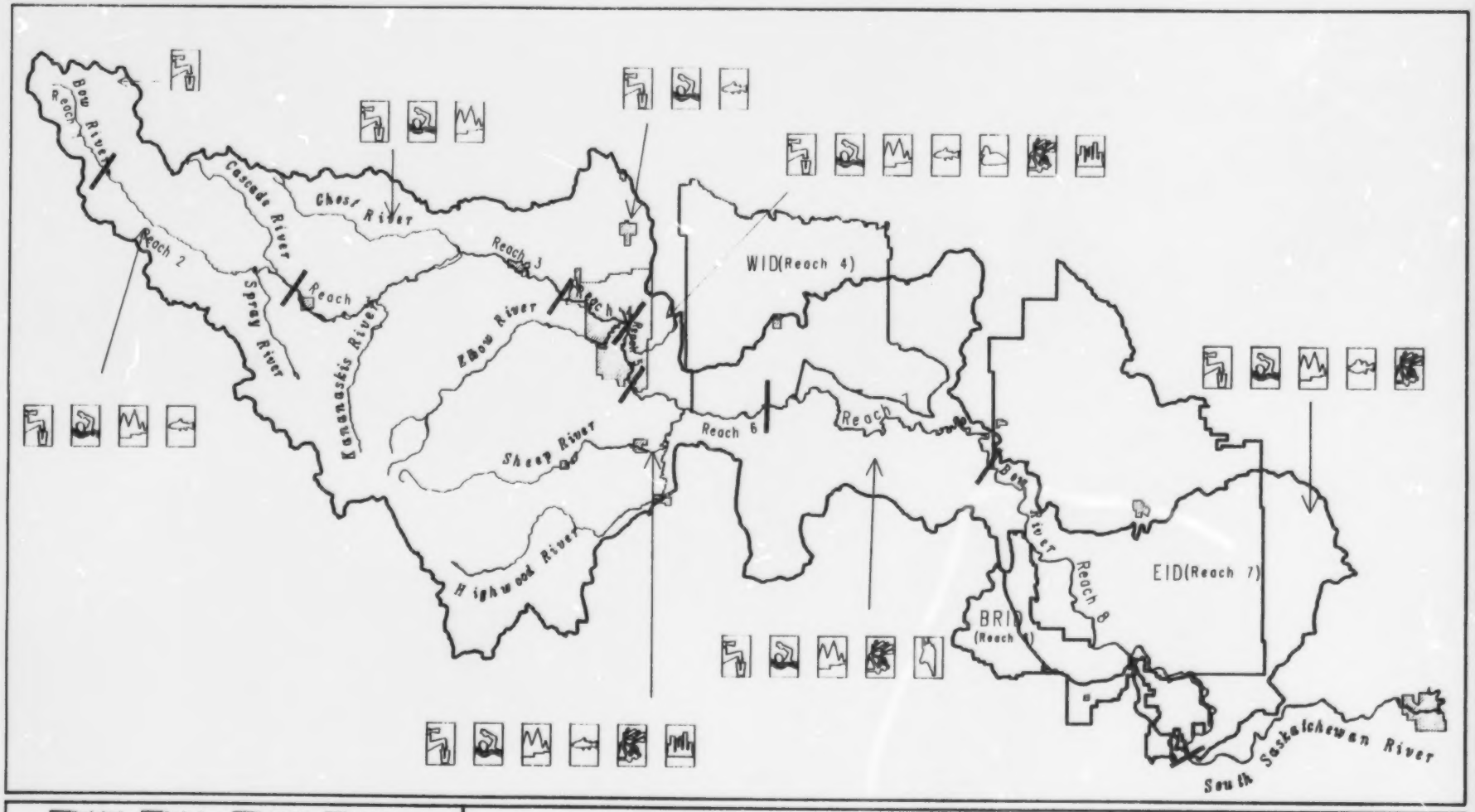
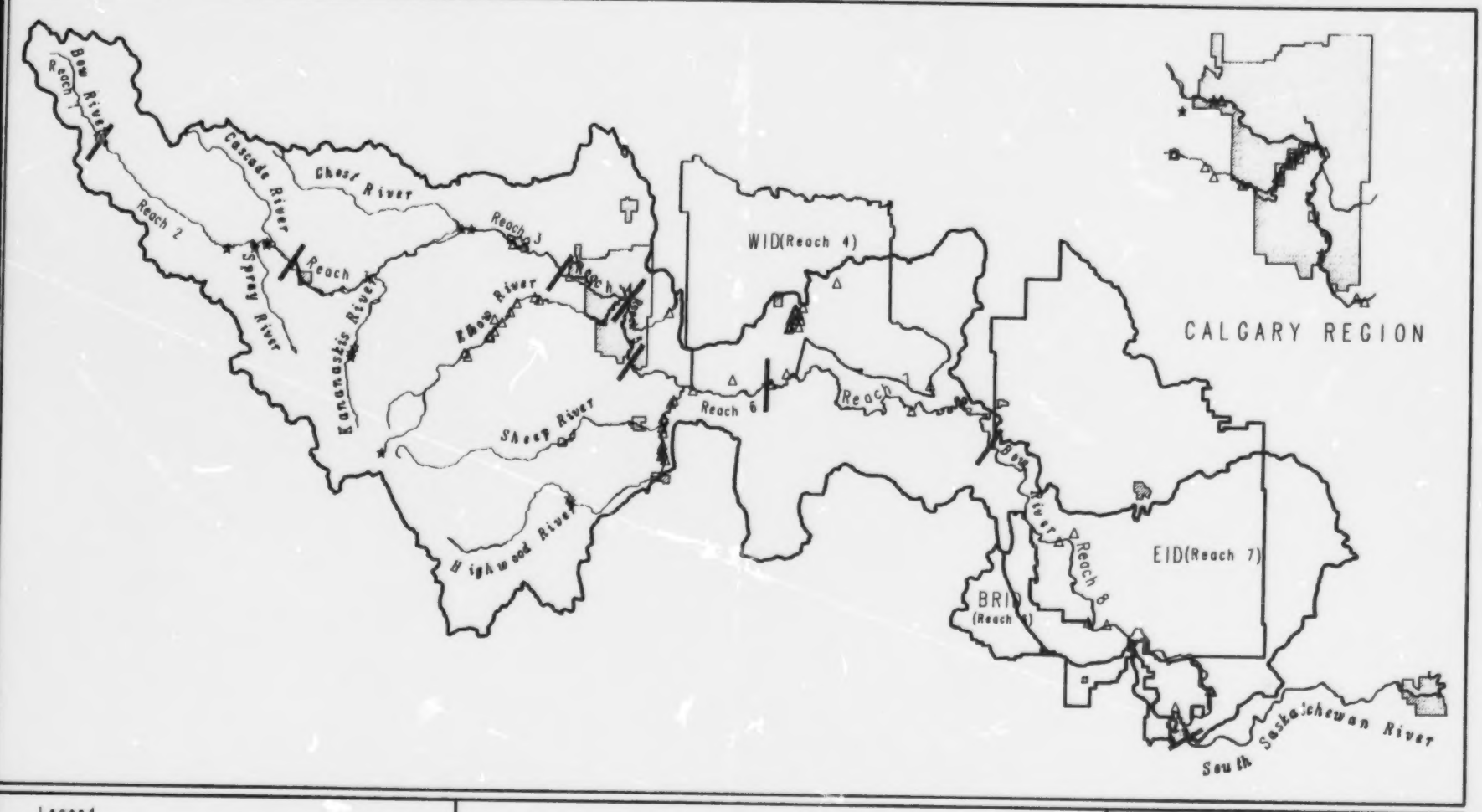


Figure 3

Water Use Impairment in the Bow River Basin

Produced by EMA
November 1991

Bow River
WATER QUALITY
TASK FORCE



Legend

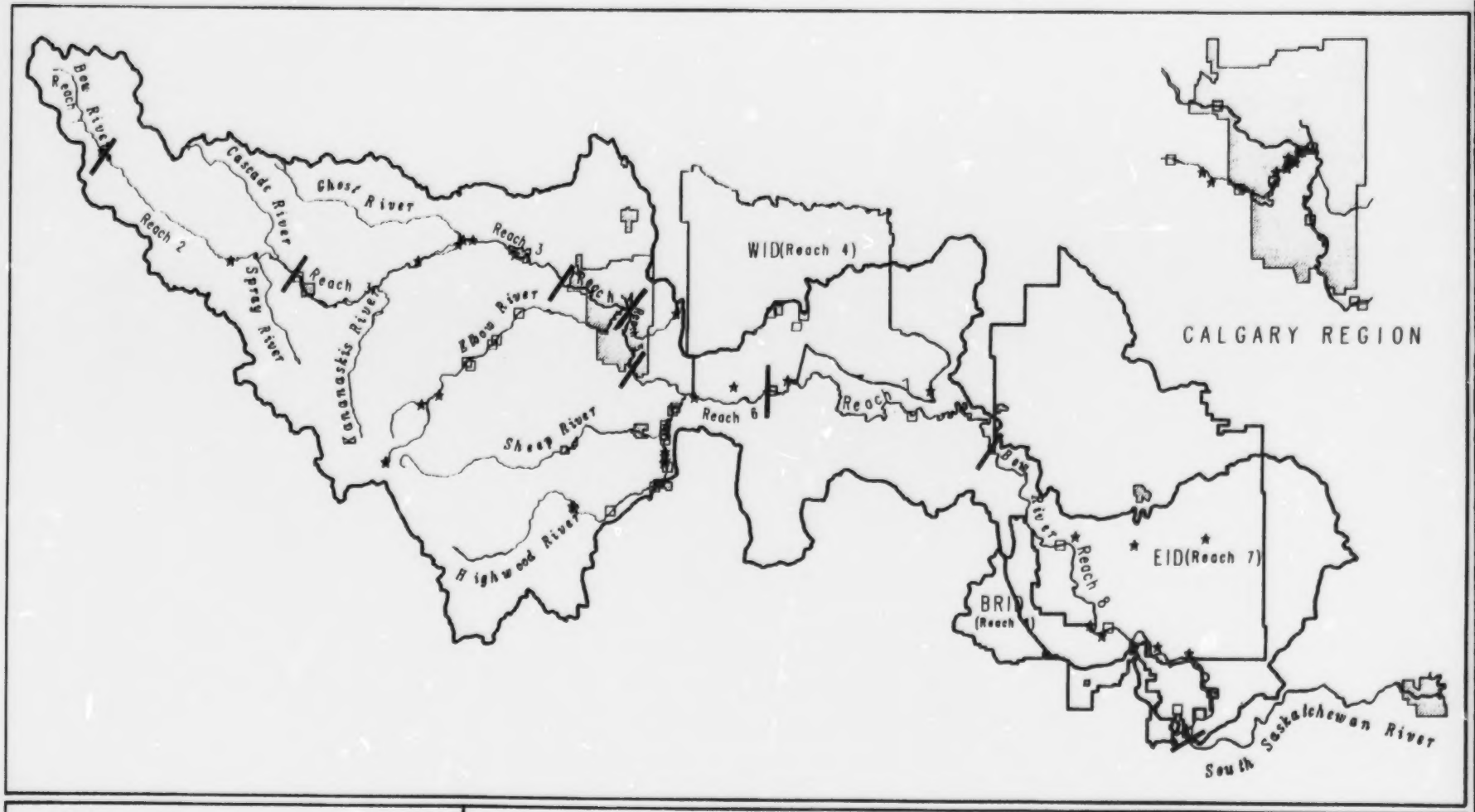
- ★ Level I
- □ Level II
- △ Level III

Figure 4

Raw Water Quality for Domestic and Municipal Supply

Produced by EMA
November 1991

Bow River WATER QUALITY TASK FORCE



Legend

★ Complies with guidelines

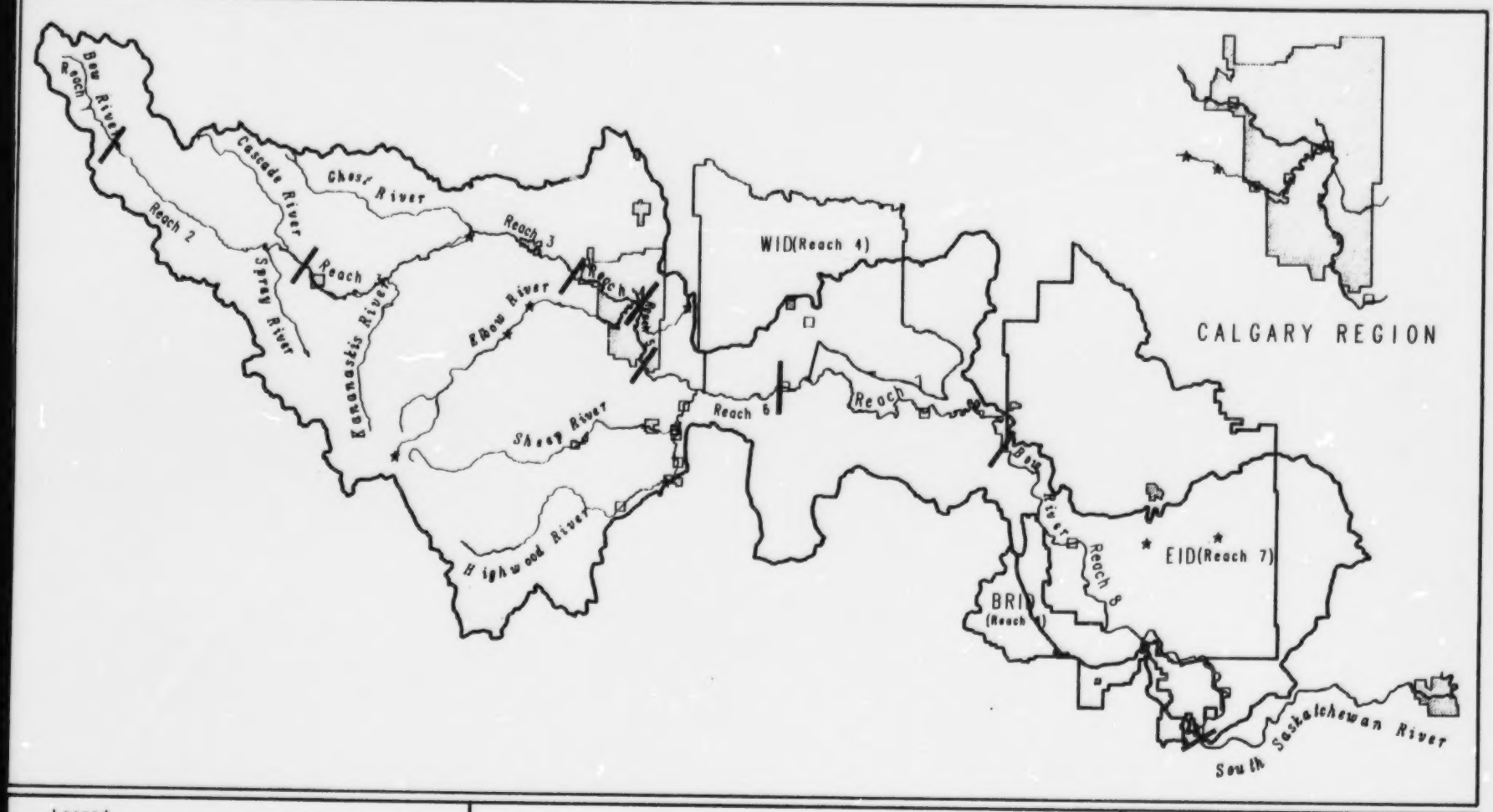
□ Non compliant

Figure 5

Contact Recreation Compliance Summary

Produced by EWA
November 1991

Bow River
WATER QUALITY
TASK FORCE



Legend

★ Complies with guidelines

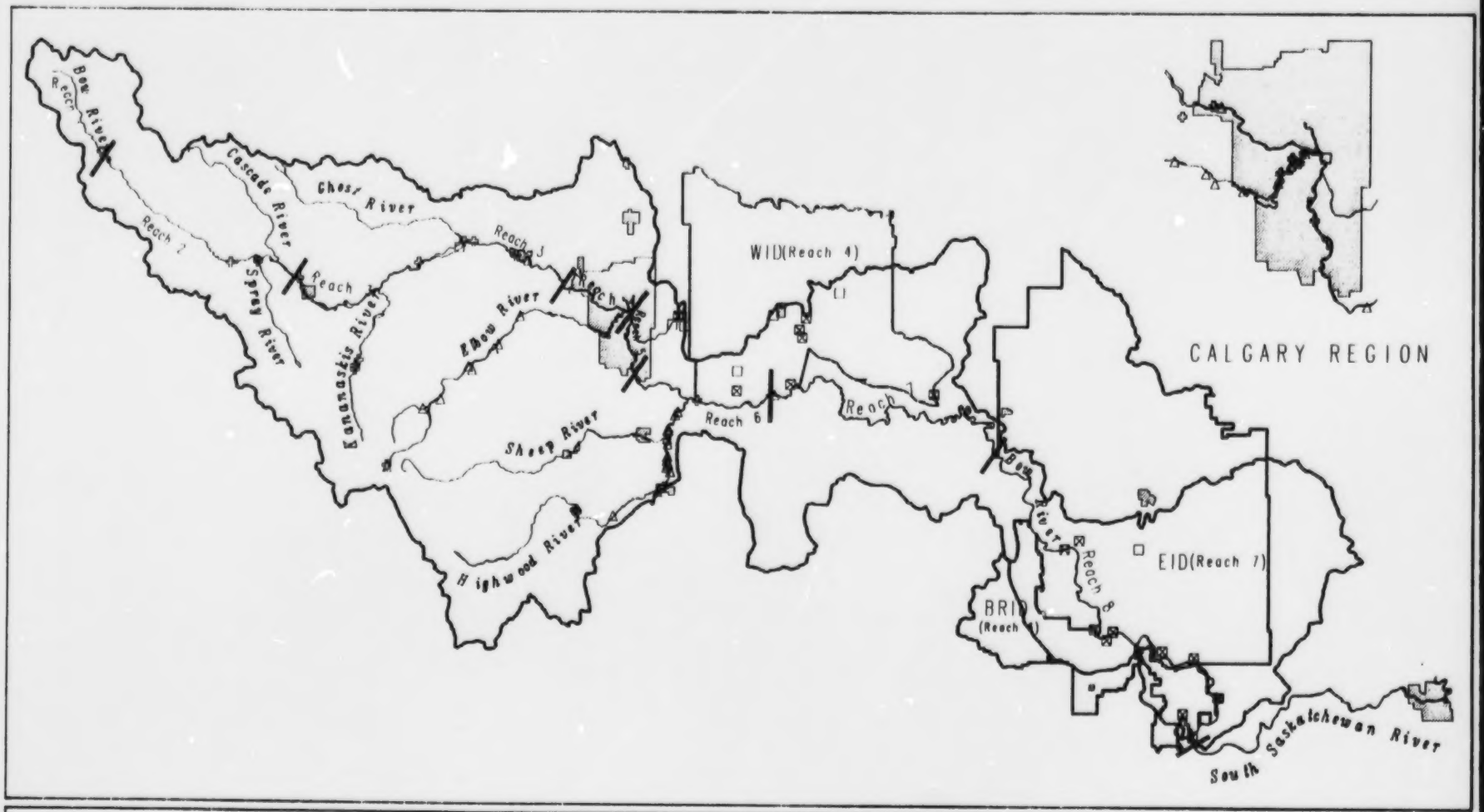
□ Non-compliant

Figure 6

Aesthetic Enjoyment Compliance Summary

Produced by EMA
November 1991

Bow River
WATER QUALITY
TASK FORCE



Legend

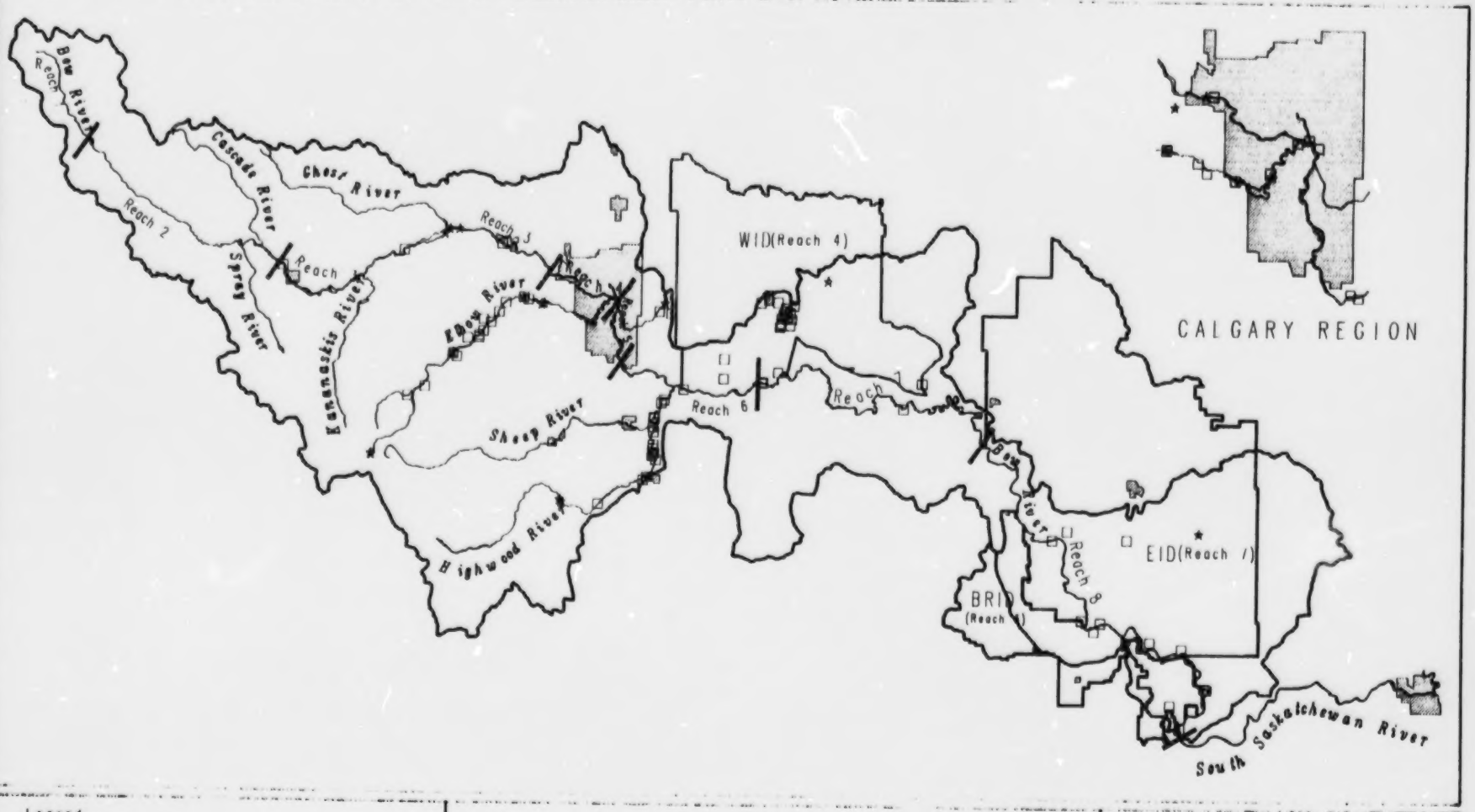
- Warm water compliance
- Warm water non-compliance
- Cold water compliance
- Cold water non compliance
- Cold and Warm water compliance

Figure 7

Aquatic Life Compliance Summary

Produced by EMA
November 1991

Bow River WATER QUALITY TASK FORCE



Legend

★ Complies with guidelines

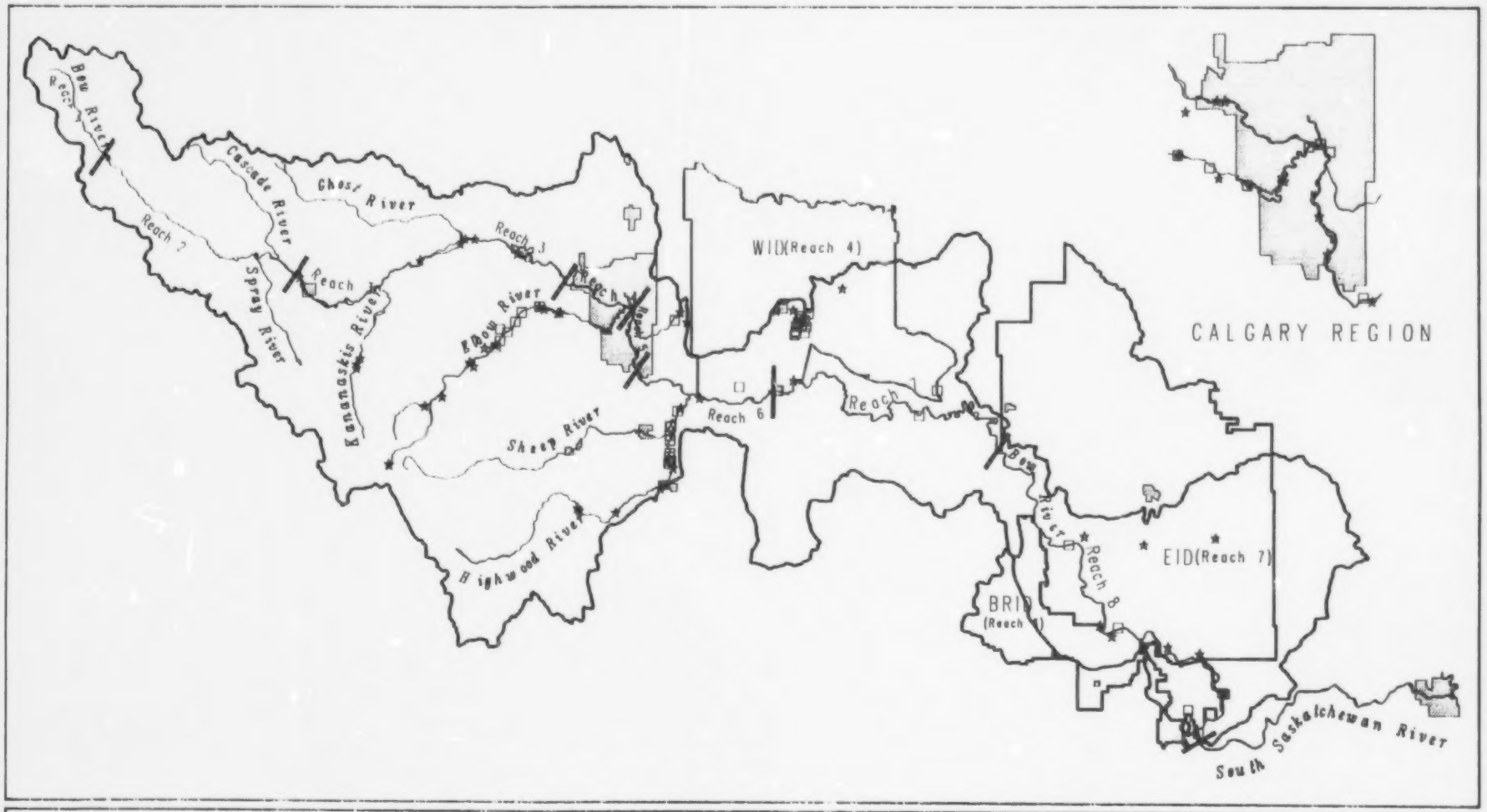
□ Non-compliant

Figure 8

Irrigation Water Compliance Summary

Produced by EMA
November 1991

Bow River
WATER QUALITY
TASK FORCE



Legend

★ Complies with guidelines

[] Non-compliant

Figure 9

Livestock Watering Compliance Summary

Produced by EMA
November 1991

Bow River
WATER QUALITY
TASK FORCE

2.3.3 Evaluation of Drinking Water Supplies

Municipal Branch, Alberta Environment, periodically conducts surveys of raw and treated municipal drinking waters for a wide variety of conventional variables and trace organic contaminants (Table 14). Since 1985, violations with drinking water guidelines were noted for iron (Turner Valley and High River), manganese (Hussar, Suffield, Enchant and Lomond), and lead (Canmore) (Table 15). Violations for iron and manganese are likely attributable to high concentrations of these metals in the raw water, and the lead violation may have resulted from particulate lead originating in the delivery system rather than the source water.

Relative to the large number of trace organic compounds analyzed there were few at detectable levels (Table 16). Concentrations of those compounds detected were generally low, and with the exception of ethylbenzene levels in Brooks drinking water during one occasion in 1985, levels of all trace organics were well below drinking water guidelines. However, the guideline for ethylbenzene is related to aesthetics and is well below the value considered to constitute a health hazard.

A number of those components detected (e.g., hexadeconoic acid and the phthalates) are often detected even in distilled and deionized water and are probably indicative of contamination from sampling bottles, reagents, or laboratory equipment. The trihalomethanes bromodichloromethane, dibromochloromethane, and chloroform and other chlorinated organics are likely a product of chlorination of the water supply.

Table 14. Drinking Water Survey – Compounds Tested

Parameter	Detection Limit	CDW * Guideline	Parameter	Detection Limit	CDW * Guideline	Parameter	Detection Limit	CDW * Guideline
Routine – Heavy Metals			Routine – Heavy Metals (cont'd)			Chlorinated Pest. (cont'd)	ug/L	
PH (NO UNITS)	N/A	Y	COBALT	<0.001		B- "	<0.010	
IRON	<0.001	Y	NICKEL	<0.001		Y- "	<0.010	
CALCIUM	<0.1		LEAD	<0.002	Y	g- "	<0.010	
HARDNESS T	<1.	Y	MANGANESE	<0.001	Y	Methoxychlor	<0.030	Y
POTASSIUM	<0.1		BERYLLIUM	<0.001		Mirex	<0.020	
NO2 + NO3	<0.01		MOLYBDENUM	<0.001		Perthane	<0.250	
FLUORIDE	<0.01	Y	BARIUM	<0.001	Y	Ramrod (Propachlor)	<0.100	
SULFATE	<1.	Y				Triallate (avadex BW)	<0.040	
ALKALINITY	<1.							
TC (PARTIC)	<0.02		Chlorinated Pesticides	ug/L				
TURBIDITY (NTU)	<0.1	Y	Aldrin	N/A	Y	Polychlorinated Biphenols	ug/L	
CONDUCTIVITY	<1.		Alachlor	<0.040		Aroclor 1016	<0.10	
TDS	<1.	Y	a-Chlordane	<0.020	Y	Aroclor 1221	<0.20	
MAGNESIUM	<0.1		Y-Chlordane	<0.005	Y	Aroclor 1232	<0.10	
SODIUM	<0.1	Y	Captan	<0.150		Aroclor 1242	<0.05	
SILICA	<0.1		Dacthal	<0.010		Aroclor 1248	<0.05	
NITRITE	<0.001	Y	o,p'-DDD	<0.010		Aroclor 1254	<0.05	
CHLORIDE	<0.1	Y	p,p'-DDD	<0.010		Aroclor 1260	<0.10	
BICARBONATE	<1.		o,p'-DDE	<0.010		Aroclor 1262	<0.10	
DOC	<0.1		p,p'-DDE	<0.010		Aroclor 1268	<0.05	
DIC	<0.1		o,p'-DDT	<0.020	Y			
ARSENIC	<0.0001	Y	p,p'-DDT	<0.020	Y			
BORON	<0.001	Y	Diallate(Avadex)	<0.800		Organophosphorus	ug/L	
COPPER	<0.001	Y	Dieldrin	<0.010	Y	Aspon	<0.50	
CADMIUM	<0.001	Y	Dursban	<0.012		Crufomate	<2.00	
ZINC	<0.001	Y	a-Endosulfan	<0.010		Dasanit	<4.00	
CHROMIUM	<0.001	Y	B-Endosulfan	<0.010		DDVP	<0.20	
VANADIUM	<0.002		Endrin	<0.010		DEF	<0.05	
ALUMINUM	<0.002		Heptachlor	<0.010	Y	Demeton	<7.00	
TN (PARTIC)	<0.02		Heptachlor epoxide	<0.010	Y	Dimethoate	<0.15	Y
MERCURY	<0.0001	Y	Hexachlorobenzene	<0.005		Di-Syston	<25.00	
SELENIUM	<0.0001	Y	a-Hexachlorocyclohexane	<0.010		Ethion	<0.05	

* Canadian Drinking Water Guidelines, Health and Welfare Canada (1989)

Table 14. Drinking Water Survey – Compounds Tested (continued)

Parameter	Detection Limit	CDW * Guideline	Parameter	Detection Limit	CDW * Guideline	Parameter	Detection Limit	CDW * Guideline
Organophosphorus (cont'd)	ug/L		Volatile Compounds	ug/L		Volatile Compounds (cont'd)	ug/L	
Fenthion	<1.25		Benzene	<1.00	Y	Vinyl Chloride	<30.00	
Fenitrothion	<0.05		Bromochloromethane	<1.00		o-Xylene	<1.00	Y
Fonofos	<0.05		Bromodichloromethane	<1.00	Y	m,p-Xylene	<1.00	Y
Guthion	<2.00		Bromoform	<5.00				
Malathion	<0.17	Y	Bromomethane	<1.00				
Methyl Parathion	<0.05		Carbon tetrachloride	<1.00	Y	Semivolatile Compounds	ug/L	
Methyl Trithion	<0.25		Chlorobenzene	<1.00		Benzoic Acid	<2.00	
Mevinphos	<0.20		Chloroethane	<1.00		4-Chloro-3-methylphenol	<1.00	
Mocap	<0.15		2-Chloroethoxyethylene	<4.00		2-Chlorophenol	<2.00	
Paraoxon	<0.10		Chloroform	<1.00	Y	2,4-Dichlorophenol	<1.00	Y
Parathion	<0.06	Y	Dibromochloromethane	<1.00	Y	2,4-Dimethylphenol	<2.00	
Phorate	<0.20	Y	1,2-Dichlorobenzene	<1.00	Y	2-Methyl-4,6-Dinitrolphenol	<1.00	
Ronnel	<0.10		1,3-Dichlorobenzene	<1.00		2,4-Dinitrophenol	<1.00	
Tetrachlorvinphos	<0.03		1,4-Dichlorobenzene	<1.00	Y	Hexadecanoic acid	<3.00	
			1,1-Dichloroethane	<1.00		2-Nitrophenol	<1.00	
			1,2-Dichloroethane	<1.00	Y	4-Nitrophenol	<1.00	
Organonitrogen	ug/L		1,1-Dichloroethylene	<1.00		Pentachlorophenol	<1.00	Y
Atrazine	<1.00	Y	trans-1,2-Dichloroethylene	<1.00		Phenol	<1.00	
Aminocarb	<100.00		1,2-Dichloropropane	<1.00		2,4,5-Trichlorophenol	<1.00	
Bromacil	<0.05		cis-1,3-Dichloropropylene	<3.00		2,4,6-Trichlorophenol	<1.00	Y
Cobex	<0.03		trans-1,3-Dichloropropylene	<3.00		Acenaphthene	<1.00	
Cyanazine	<0.03	Y	Ethyl benzene	<1.00	Y	Acenaphthylene	<1.00	
Diazinon	<0.50	Y	Methylene chloride	<1.00		Anthracene	<1.00	
Dinoseb	<0.15		Styrene	<1.00		Benzo(a)anthracene	<1.00	
Metribuzin	<0.03	Y	1,1,2,2-Tetrachloroethane	<1.00		Benzo(k)fluoranthene	<1.00	
Prometryne	<1.50		Tetrachloroethylene	<3.00		Benzo(ghi)perylene	<2.00	
Propanil	<0.70		Toluene	<1.00	Y	Benzo(a)pyrene	<1.00	Y
Propazine	<1.00		1,1,1-Trichloroethane	<1.00		Chrysene	<1.00	
Simazine	<1.00	Y	1,1,2-Trichloroethane	<1.00		Dibenzo(ah)anthracene	<5.00	
Terbacil	<0.10		Trichloroethylene	<1.00	Y	Fluoranthene	<1.00	
Trifluralin (Treflan)	<0.03	Y	Trichlorofluoromethane	<1.00		Fluorene	<1.00	

* Canadian Drinking Water Guidelines, Health and Welfare Canada (1989)

Table 14. Drinking Water Survey – Compounds Tested (continued)

Parameter	Detection Limit	CDW * Guideline	Parameter	Detection Limit	CDW * Guideline
Semivolatile Compounds (cont'd)	ug/L		Chlorinated Herbicide acids	ug/L	
Indeno(1,2,3-cd)pyrene	<1.00		Two,4-D	<0.20	Y
Napthalene	<1.00		Dicamba	<0.20	Y
Perylene	<1.00		Diclofop-methyl (Hoe Grass)	<0.20	Y
Phenanthrene	<1.00		MCPA	<0.20	
Pyrene	<1.00		Picloram	<0.30	Y
Benzo(b)Fluoranthene	<1.00		Two,4,5-T	<0.20	Y
2-Chloronaphthalene	<1.00		Silvex	<0.30	
Hexachlorobenzene	<1.00		2,4-DP	<0.20	
Hexachlorobutadiene	<5.00		2,4-DB	<0.30	
Hexachlorocyclopentadiene	<1.00				
Hexachloroethane	<5.00				
1,2,4-Trichlorobenzene	<1.00				
Isophorone	<1.00				
Benzidine	<2.00				
2,4-Dinitrotoluene	<1.00				
2,6-Dinitrotoluene	<1.00				
1,2-Diphenylhydrazine	<1.00				
Nitrobenzene	<1.00				
N-Nitrosodiphenylamine	<1.00				
N-Nitrosodi-n-propylamine	<2.00				
4-Bromophenyl phenyl ether	<1.00				
Bis(2-chloroethoxy)methane	<1.00				
Bis(2-chloroethyl)ether	<1.00				
Bis(2-chloroisopropyl)ether	<1.00				
4-Chlorophenyl phenyl ether	<1.00				
Butylbenzylphthalate	<1.00				
Dibutylphthalate	<1.00				
Diethylphthalate	<1.00				
Dimethylphthalate	<1.00				
Di-n-octylphthalate	<1.00				
Bis(2-ethylhexyl)phthalate	<1.00				

* Canadian Drinking Water Guidelines, Health and Welfare Canada (1989)

Table 15. Treated Drinking Water Survey – Metal and Trace Elements (1985 – 1990)

Parameter	Town	Turner Valley	Arrowwood	Carseland	Glaichen	Hussar	Standard	Strathmore	Brooks	Hays	Rainier	Rolling Hills	Scandia	Suffield	Kinbrook Island	CDW* Guidelines
	Source	Sheep River	E. Arrow. Creek	Bow River	WID	Deadhorse Lake	Crowfoot Creek	WID	EID	?	EID	EID	EID	Ralston	EID	
Arsenic	# Samples	7	6	3	6	3	3	6	29	3	2	2	5	8	2	0.05
	# Above Detect.	2	6	2	6	3	3	4	29	3	2	2	5	7	2	MAC
mg/L	Maximum	0.0003	0.0005	0.0003	0.0016	0.0007	0.002	0.001	0.0012	0.0007	0.0005	0.0006	0.0014	0.0068	0.0008	
	Violation (V)															
Manganese	# Samples	7	6	3	7	4	4	6	39	3	2	2	5	8	2	0.05
	# Above Detect.	3	5	1	5	4	1	3	17	3	2	1	5	6	2	AO
mg/L	Maximum	0.022	0.015	0.002	0.023	0.117	0.008	0.008	0.014	0.034	0.023	0.014	0.034	0.094	0.013	
	Violation (V)					V								V		
Selenium	# Samples	7	6	3	6	3	3	6	29	3	2	2	5	8	2	0.01
	# Above Detect.	0	2	0	0	0	0	0	3	0	0	0	0	0	0	MAC
mg/L	Maximum		0.0025						0.0003							
	Violation (V)															
Barium	# Samples	7	6	3	6	2	3	6	28	3	2	2	5	9	2	1.0
	# Above Detect.	7	6	3	6	2	3	6	28	3	2	2	5	8	2	IMAC
mg/L	Maximum	0.12	0.03	0.023	0.093	0.015	0.022	0.066	0.062	0.093	0.076	0.072	0.076	0.074	0.066	Proposed
	Violation (V)															
Copper	# Samples	7	5	3	7	4	4	6	39	3	2	2	5	8	2	1.0
	# Above Detect.	7	5	3	6	4	4	6	39	3	2	2	5	6	2	AO
mg/L	Maximum	0.076	0.033	0.051	0.121	0.049	0.049	0.026	0.778	0.012	0.036	0.028	0.042	0.174	0.026	
	Violation (V)															
Cadmium	# Samples	7	6	3	7	4	4	6	39	3	2	2	5	8	2	0.005
	# Above Detect.	2	6	1	5	0	0	4	10	2	0	1	2	7	1	MAC
mg/L	Maximum	0.002	0.004	0.004	0.002			0.003	0.014	0.002		0.003	0.004	0.01	0.001	
	Violation (V)															
Zinc	# Samples	7	6	3	7	4	4	6	39	3	2	2	5	8	2	5.0
	# Above Detect.	7	6	3	3	4	3	2	37	3	2	2	5	7	2	AO
mg/L	Maximum	0.215	0.048	0.034	0.005	0.057	0.015	0.004	0.024	0.005	0.012	0.02	0.035	0.057	0.044	Proposed
	Violation (V)															
Chromium	# Samples	7	6	3	7	4	4	6	39	3	2	2	5	8	2	0.05
	# Above Detect.	6	6	3	6	3	1	6	30	3	1	1	3	7	1	MAC
mg/L	Maximum	0.005	0.008	0.003	0.004	0.003	0.004	0.004	0.032	0.006	0.004	0.002	0.003	0.007	0.002	
	Violation (V)															
Iron	# Samples	3	1	1	4	1	2	3	10	1	1	0	1	3	2	0.3
	# Above Detect.	3	0	1	4	1	2	3	9	1	1		1	3	1	AO
mg/L	Maximum	0.88		0.108	0.092	0.049	0.039	0.044	0.092	0.041	0.076		0.042	0.188	0.05	Proposed
	Violation (V)	V														
Lead	# Samples	7	6	3	7	4	4	6	39	3	3	3	6	9	2	0.01
	# Above Detect.	0	1	0	0	0	0	1	0	0	0	1	2	1	0	MAC
mg/L	Maximum		0.005					0.007				0.002	0.004	0.004		Proposed
	Violation (V)															

* – Canadian Drinking Water Guidelines (Health and Welfare Canada, 1989). (I)MAC – (interim) maximum allowable concentration, AO – asthetic objective.

Table 15. Treated Drinking Water Survey – Metal and Trace Elements (1985 – 1990)

Parameter	Town	Badger Lake	Enchant	Banff	Canmore	Airdrie	Calgary	Calgary	Cochrane	Black Diamond	High River	Longview	Okotoks	CDW* Guidelines
	Source	BRID	BRID	40 mile Creek	Spray Lake	Bow River	Bow R. Bearspaw	Elbow R. Glenmore	Bow River	Sheep River	Highwood River	Highwood River	Sheep River	
Arsenic	# Samples	0	11	1	9	2	61	66	8	8	13	3	13	0.05
	# Above Detect.		11	0	1	1	15	23	3	2	0	1	4	MAC
mg/L	Maximum		0.0022		0.0002	0.001	0.0014	0.001	0.0006	0.0003		0.0004	0.0006	
	Violation (V)													
Manganese	# Samples	1	11	1	9	2	72	77	8	9	15	3	17	0.05
	# Above Detect.	1	7	0	1	0	15	14	3	3	6	0	4	AO
mg/L	Maximum	0.013	1.177		0.008		0.008	0.021	0.008	0.008	0.018		0.018	
	Violation (V)		V											
Selenium	# Samples	0	11	1	9	2	61	66	8	8	13	3	13	0.01
	# Above Detect.		2	0	2	0	4	5	3	0	0	1	0	MAC
mg/L	Maximum		0.0005		0.0003		0.001	0.0028	0.004			0.0004		
	Violation (V)													
Barium	# Samples	0	11	1	9	2	61	66	8	8	15	3	13	1.0
	# Above Detect.		11	1	8	2	61	66	8	8	15	3	13	IMAC
mg/L	Maximum		0.095	0.029	0.017	0.034	0.051	0.085	0.052	0.066	0.13	0.099	0.104	Proposed
	Violation (V)													
Copper	# Samples	1	12	1	9	2	72	77	8	8	14	3	17	1.0
	# Above Detect.	1	12	1	6	2	42	45	8	8	14	3	17	AO
mg/L	Maximum	0.004	0.472	0.015	0.038	0.015	0.062	0 011	0.081	0.2	0.167	0.06	0.128	
	Violation (V)													
Cadmium	# Samples	1	11	1	9	2	73	78	8	9	15	3	17	0.005
	# Above Detect.	1	8	1	4	1	24	30	1	4	8	0	7	MAC
mg/L	Maximum	0.002	0.005	0.002	0.003	0.002	0.004	0.003	0.002	0.002	0.002		0.003	
	Violation (V)		**											
Zinc	# Samples	1	11	1	9	2	72	77	8	9	15	3	17	5.0
	# Above Detect.	1	11	1	6	1	40	38	8	7	15	3	13	AO
mg/L	Maximum	0.012	0.045	0.006	0.004	0.005	0.034	0.018	0.012	0.005	0.199	0.228	0.029	Proposed
	Violation (V)													
Chromium	# Samples	1	11	1	9	2	73	78	8	9	15	3	17	0.05
	# Above Detect.	1	10	1	7	2	52	63	8	7	12	2	12	MAC
mg/L	Maximum	0.003	0.009	0.003	0.014	0.004	0.012	0.014	0.014	0.009	0.007	0.004	0.013	
	Violation (V)													
Iron	# Samples	0	4	1	5	0	30	35	4	3	6	0	4	0.3
	# Above Detect.		4	1	4		27	24	4	3	6		3	AO
mg/L	Maximum		0.281	0.028	0.05		0.127	0.12	0.053	0.443	0.062		0.073	Proposed
	Violation (V)									V				
Lead	# Samples	1	11	1	9	2	73	78	8	9	13	3	18	0.01
	# Above Detect.	0	1	0	1	1	9	5	0	3	1	1	1	MAC
mg/L	Maximum		0.006		0.034	0.004	0.008	0.007		0.005	0.006	0.005	0.004	Proposed
	Violation (V)				V									

* – Canadian Drinking Water Guidelines (Health and Welfare Canada, 1989). (I)MAC – (interim) maximum allowable concentration, AO – asthetic objective.

Table 16. Treated Drinking Water Survey - Trace Organic Compounds (1985-1989).
Values in the table are the number of samples above detection and the maximum concentration (µg/L, in parentheses).

	Town	Arrowwood	Bassano	Black Diamond	Brooks	Calgary Bearspaw	Calgary Glenmore	Canmore	Cochrane	Duchess	Gleichen	Lomond	Mount Allen	Okotoks	Patricia	Standard	Strathmore	Tilley
	Number of Samples	1	1	1	30	60	60	7	7	1	2	1	1	2	1	2	2	1
Compound	CDW Guideline (ug/L)																	
Volatile Compounds																		
Benzene	5		1 (tr.)		5 (2)	8 (tr.)	5(tr.)	1 (tr.)	2 (tr.)			1 (tr.)						
Bromochloromethane						1 (2)	1 (2)		3 (tr.)	1 (8)								
Bromodichloromethane	350		1 (9)	1 (1)	29 (36)	30 (6.7)	38 (8.3)		7 (9)		2 (7)	1 (6)		2 (4.4)	1 (tr.)	2 (9)	2 (6)	1 (12)
Carbon Tetrachloride	5				1 (tr.)													
Chloroform	350		1 (46)	1 (9)	30 (230)	59 (110)	60 (180)	5 (10)		1 (46)	2 (58)	1 (46)	1 (1)	2 (21)		2 (22)	2 (38)	1 (26)
Dibromochloromethane					3 (tr.)											1 (1)		
1,2-Dichlorobenzene	200				4 (tr.)	1 (tr.)	1 (tr.)								1 (tr.)			
1,3-Dichlorobenzene					3 (tr.)	1 (tr.)	1 (tr.)								1 (tr.)			
1,4-Dichlorobenzene	5				3 (tr.)	1 (tr.)	1 (tr.)								1 (tr.)			
2,4-Dinitrotoluene							1 (tr.)											
Ethyl Benzene	2.4*				3 (5.7)		4 (0.6)							1 (0.7)				
Toluene	24*		1 (tr.)		12 (3)	13 (tr.)	18 (2.7)	4 (tr.)	3 (tr.)			1 (tr.)	1 (tr.)	1 (1.3)	1 (tr.)		1 (tr.)	
1,1,1-Trichloroethane							3 (tr.)											
Trichlorofluoromethane					5 (0.6)	2 (tr.)	2 (tr.)											
Vinyl Chloride						1 (tr.)												
o-Xylene	300*				2 (3.6)		2 (tr.)											
m,p-Xylene	300*				4 (5.7)	1 (tr.)	7 (0.6)											
Semivolatile Compounds																		
Benzidine						1 (tr.)		1 (tr.)										
Benzoic Acid						3 (tr.)	3 (5)											
2-Chloronaphthalene					1 (tr.)	1 (tr.)	1 (tr.)										1 (tr.)	1 (tr.)
Hexadecanoic Acid					4 (tr.)	5 (4)	3 (tr.)	1 (tr.)	2 (tr.)	1 (3)								
Naphthalene						2 (tr.)	2 (tr.)										2 (tr.)	1 (6)
Phenol							1 (tr.)						1 (tr.)					
Bis(2-ethylhexyl)phthalate					15 (5)	44 (16)	46 (14)	3 (5)	6 (7)		1 (1)		1 (3)	2 (7.6)	1 (1)		2 (3)	1 (2)
Butylbenzylphthalate					23 (6.3)		2 (tr.)	1 (3)										
Dibutylphthalate			1 (tr.)		11 (tr.)	27 (1)	31 (2)	3 (tr.)	4 (tr.)			1 (tr.)	1 (tr.)	1 (tr.)	1 (tr.)	1 (1)	2 (tr.)	1 (tr.)
Diethylphthalate					2 (tr.)	11 (tr.)	4 (tr.)	2 (tr.)	2 (tr.)				1 (tr.)					
Dimethylphthalate					1 (tr.)													1 (tr.)
Di-n-octylphthalate						3 (1.2)	1 (tr.)							1 (tr.)				

* Aesthetic Objectives, no guideline for maximum acceptable concentration

2.3.4 Overview of Aquatic Plants and Benthic Algae

Alberta Environment conducted near-shore transect surveys of aquatic plants in Reaches 5 and 6 between 1981 and 1986 and a synoptic survey of aquatic plants in Reach 5 and 5 in 1989. Sites in Reaches 5, 6, and 7 were also surveyed in 1990. No database is used to store aquatic plant data.

The near-shore transect surveys provide an indication of peak aquatic plant densities, whereas the 1989 and 1990 synoptic surveys provide information to derive average peak plant densities for each reach. Peak plant densities in individual beds are in the order of 1200 g/m^2 dry weight, whereas maximum peak plant densities averaged over the entire reach are around 300 g/m^2. Reach average peak aquatic plant densities are summarized below. The data are subdivided into low (1989) and high (1990) discharge conditions, to compensate for the effect of scour and light limitation.

The density of aquatic plants varies considerably throughout the Bow River (Table 17). In general, densities are very low upstream of the Bonnybrook STP (Reaches 1 to 4 and part of 5). Reach 5, downstream of Bonnybrook, supports the highest density of aquatic plants as a result of nutrient loadings from the Bonnybrook and Fish Creek STP's. Plant densities decline downstream into Reaches 6 and 7; no data are available for Reach 8.

The hydrologic conditions in the river can have a profound effect on aquatic plant densities. High river velocities associated with high discharge conditions during the spring freshet can cause extensive scouring of the river bed, which result in the disruption of the rooting zone of aquatic plants. The effect of variable discharge is quite dramatic in the Bow River and has resulted in an order of magnitude difference in aquatic plant densities between low (1989) and high (1990) discharge years.

Benthic chlorophyll data are collected at the long-term monitoring sites and are commonly measured as a part of other monitoring programs. Evaluation of 1985 to 1990 benthic chlorophyll data was presented in Section 2.3.2; however, a significant amount of data was also collected in 1984. Summer-average benthic chlorophyll levels for low discharge conditions for 1984 through 1989 are summarized below. There are insufficient data to characterize benthic chlorophyll levels during high discharge conditions. In general, benthic chlorophyll levels will be lower during high-discharge conditions, but they will recover more rapidly than aquatic plants following high discharge events.

The testing of low discharge aquatic plant and benthic chlorophyll levels and high discharge aquatic plant levels against surface water quality objectives is summarized in Table 18. Under low discharge conditions aquatic plant densities in Reach 5 violate objectives for contact recreation, aesthetic enjoyment, cold and warm ecosystems, and for irrigation and industrial water supply. Contact recreation objectives for aquatic plants are also not met in Reach 6 and may not be met in Reaches 7 or 8, however, there are no data for these reaches. All aquatic plant objectives are met during high discharge years. Under low discharge conditions, benthic chlorophyll levels in Reaches 5, 6, and 7 violate objectives for contact recreation, aesthetic enjoyment, cold and warm ecosystems and for irrigation and industrial water supply.

Table 17.
PEAK AQUATIC PLANT DENSITIES AND MEDIAN SUMMER BENTHIC ALGAE DENSITIES (AS CHOROPHYLL).

REACH	AQUATIC PLANTS (g/m2)		BENTHIC CHL (mg/m2)
	LOW FLOW	HIGH FLOW	LOW FLOW
1	<10	<5	<10
2	<10	<5	<10
3	<10	<5	<10
4	<10	<5	<10
5	290	25	123
6	120	12	203
7	(no data)	8	220
8	(no data)	(no data)	68

	Ranges	
Legend	Macrophytes	Benthic Chl
LOW	<75	<50
MED	75–200	50–100
HIGH	>200	>100

Table 18. COMPLIANCE SUMMARY FOR AQUATIC PLANTS AND BENTHIC ALGAE (AS CHLOROPHYLL).

Water Use	Contact Recreation			Aesthetic Enjoyment			Cold Water Aquatic Eco.			Warm Water Aquatic Eco.			Irrigation Water			Industry		
REACH	AL	AH	BL	AL	AH	BL	AL	AH	BL	AL	AH	BL	AL	AH	BL	AL	AH	BL
1																		
2																		
3																		
4																		
5	n		n	n		n	n		n	n		n	n		n	n		n
6	n		n			n			n			n			n			n
7	?		n	?		n	?		n	?		n	?		n	?		n
8	?		n	?			?			?			?			?		

n – Indicates non–compliance, Blank – Indicates compliance, ? – Indicates insufficient data
AL – AQUATIC PLANTS, LOW FLOW YEAR
AH – AQUATIC PLANTS, HIGH FLOW YEAR
BL – BENTHIC CHLOROPHYLL, LOW FLOW YEAR

2.3.5 Canada Creosote Database Overview

Alberta Environment has an ongoing program to monitor the effect of seepage from Canada Creosote's abandoned site on the water quality of the Bow River. A number of polycyclic aromatic hydrocarbons (PAH's) and pentachlorophenol (PCP) are being monitored. These data are summarized in Table 19.

None of the PAH's or PCP have been detected at the control site upstream of Canada Creosote. At the berm outfall, however, most of these compounds are regularly detected and PCP, benzo(a)pyrene and naphthalene have been recorded at concentrations higher than current guidelines. Both the frequency of detections and maximum concentrations recorded decline downstream of Canada Creosote. Even so, violations with the pentachlorophenol guideline have been observed as far downstream as Stiers Ranch.

Table 19. Canada Creosote Monitoring Data Summary: January 1990 to January 1991.

Compound	Detection Limit (ug/L) (1)	Criteria (ug/L)	Upstream Canada Creosote				Berm Effluent				Immediately Below Canada Creosote (5)				Policeman's Point (6)			
			Number of Samples	Number Detected	Non-Compliant	Max Conc	Number of Samples	Number Detected	Non-Compliant	Max Conc	Number of Samples	Number Detected	Non-Compliant	Max Conc	Number of Samples	Number Detected	Non-Compliant	Max Conc
Naphthalene	0.01	620 (2)	35	0	0	< 0.01	48	37	2	2000	84	73	0	52	96	17	0	1.4
C1-naphthalene	0.01		35	0	--	< 0.01	48	44	--	260	84	44	--	6.8	96	15	--	0.8
C2-naphthalene	0.01		35	0	--	< 0.01	48	46	--	64	84	30	--	5.1	96	12	--	1.1
Acenaphthylene	0.01		35	0	--	< 0.01	48	42	--	11	84	9	--	0.4	96	0	--	--
Acenaphthene	0.01		35	0	--	< 0.01	48	47	--	76	84	21	--	2.9	96	4	--	0.76
Fluorene	0.01		35	0	--	< 0.01	48	46	--	47	84	24	--	2.2	96	9	--	1.0
Phenanthrenel Anthracene	0.01		35	0	--	< 0.01	48	44	--	31	84	26	--	4.6	96	10	--	0.97
Dibenzofuran	0.01		35	0	--	< 0.01	48	46	--	15	84	20	--	2.4	96	2	--	0.33
Pentachlorophenol	0.01	0.5 (3)	35	0	0	< 0.01	48	47	43	388	84	32	6	5.1	96	11	2	3.8
Carbazole	0.02		35	0	--	< 0.02	48	44	--	79	84	12	--	1.9	96	1	--	7.3
Methyl Phenathrenel Anthracene	0.01		35	0	--	< 0.01	48	22	--	3	84	15	--	0.47	96	9	--	0.25
Benzo(a)pyrene	0.005	0.01 (4)	35	0	0	< 0.005	48	6	6	0.1	84	2	2	0.75	96	0	0	--
Benzo(a)anthracene	0.01		0	--	--	--	0	--	--	--	23	0	--	--	23	1	--	0.05
Benzo(b)fluoranthene	0.01		0	--	--	--	0	--	--	--	23	2	--	0.05	23	0	--	--

(1) Detection limit as of 23 July 1990, prior to that DL was 0.1 ug/L for all compounds except carbazole (0.2 ug/L) and benzo(a)pyrene (0.01 ug/L).
(2) U.S. Environmental Protection Agency for chronic toxicity to freshwater aquatic life
(3) Canadian Water Quality Guideline for the protection of freshwater aquatic life
(4) Guidelines for Canadian Drinking Water Quality
(5) In effluent plume
(6) Stiers Ranch monitoring site

2.3.6 Other Contaminated Groundwater Sites

The Help End Landfill Pollution (HELP) project inventory of industrial landfills identified 92 sites in the Bow River Basin that have landfills. Many of these sites are located in the Bow River Valley on sand and gravel deposits.

The location of the HELP project sites are indicated in Figure 10, and a description of each site is given in Table 20.

Within the Calgary urban area, seven industrial sites are known to have contamination (see Table 21 and Figure 11). All of these sites have been or are under investigation, with groundwater monitoring undertaken at several of the sites.

In addition, there are other industrial sites that are potentially troublesome. For example, the March 31, 1991 issue of the Calgary Herald lists a number of petro and chemical industries (some of which are now abandoned) along the Elbow River near its confluence with the Bow River that have not yet been investigated - Champion Chemical, Stewart Petroleum, Penguin Oil, Anglo American Exploration, Arctic Oil and British Petroleum.

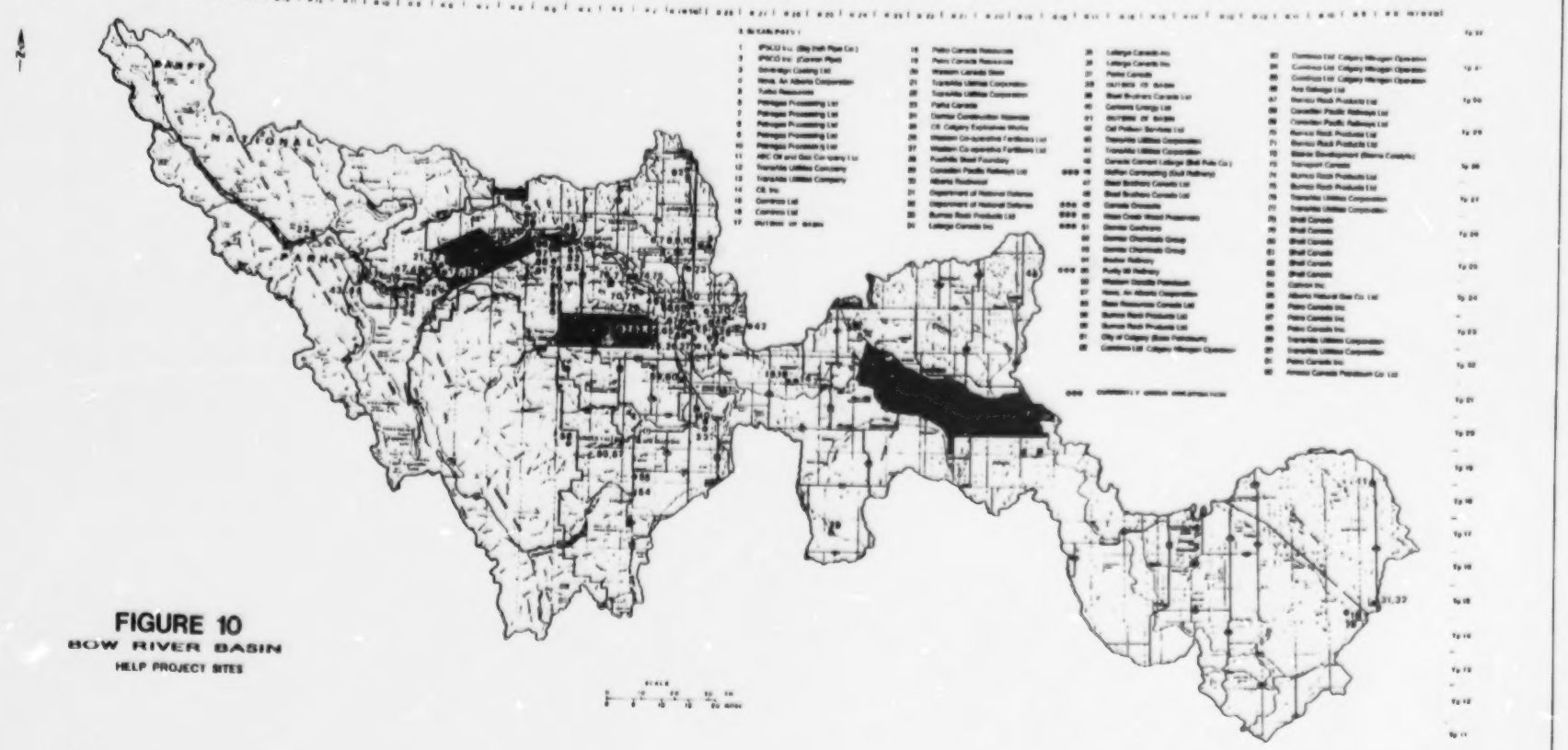


FIGURE 10
BOW RIVER BASIN
HELP PROJECT SITES

Table 20

INDUSTRIAL WASTE LANDFILL PROGRAM
HELP END LANDFILL POLLUTION, (H.E.L.P.)

INDUSTRIAL LANDFILL MANAGEMENT CONTROL SYSTEM

	COMPANY	TYPE	SUB	GRP	L/F ID	L/F LIC	L/F STAT	STATUS	SECT	TWP	RGE	W/M	AREA	OPER FROM	OPER TO	OVERALL COMMENTS	WASTE TYPES	DESIGN & OPERATION
1.	IPSCO Inc. (Big Inch Pipe Co.)	ABC	1	020	1	P	A		36	28	23	29	4 Calgary	0	0	Air photos indicate possible l/f area to south of facility. Site visit 24/11/87	Leachate tests. Surface samples taken, results in file.	Area levelled and used by IPSCO for yard space.
2.	IPSCO Inc. (Canron Pipe)	ABC	1	020	1	P	A		36	36	23	1	5 Calgary	0	0	Airphotos show large area east of fac. where waste disposed. Site visit 24/11/87	Baghouse dust, wood, slag, mill scale, cement, resin bbls, old eqpt.pipejack,etc	Dump has all waste from plt. incl. 1/2 full bbls. resin, etc.(infilled low area)
3.	Sovereign Castings Ltd.	MTL	2	013	1	P	C		35	0	24	29	4 Calgary	1963	1970	(82-WR-022)	Sand, slag.	
4.	Nova, An Alberta Corporation	BCP	6	008	6	P	C		31	0	25	19	4 Nossar	0	1987		General refuse, wood, paper. Volumes assumed.	Site reclaimed.
5.	Turbo Resources Ltd.	BCP	1	006	1	P	O		20	1	26	29	4 Balzac	1986	0	Landfarm. (82-WL-150)	Oily contaminated soil, runoff silt.	Landfarm.
6.	Petrogas Processing Ltd.	BCP	2	017	5	P	O		20	2	26	29	4 Balzac	1970	0	(83-WL-073)	Drilling muds.	
7.	Petrogas Processing Ltd.	BCP	2	017	3	P	C		35	2	26	29	4 Balzac	1967	1974	(83-WL-073)	Bauxite and alumina catalyst.	
8.	Petrogas Processing Ltd.	BCP	2	017	1	P	C		35	2	26	29	4 Balzac	1961	1967	(83-WL-073)	Gen. refuse, const. debris, filter cartridges (DEA earth filters - separate pit)	
9.	Petrogas Processing Ltd.	BCP	2	017	4	P	O		20	2	26	29	4 Balzac	1961	0	(83-WL-073)	Filter cake from DEA filters. Volumes unknown but assumed large.	
10.	Petrogas Processing Ltd.	BCP	2	017	2	P	C		35	2	26	29	4 Balzac	1967	1984	Site has four cells. (83-WL-073)	General refuse, construction debris, filter cartridges.	
11.	AEC Oil and Gas Company Ltd.	BCP	2	001	1	P	O		34	3	19	9	4 Suffield	1981	0	SW. Disposal methods approved by S & A (86-WL-047).	Iron sponge (wood chips with Fe2S3).	Lime spread on iron sponge.
12.	Trans Alta Utilities Corporation	UTL	2	005	1	P	C		21	3	25	0	5 Seebe	1975	0	Landfill inactive but not closed and covered, now using disposal service.	General refuse (90%), oily rags, paper, waste oil (8%), const. debris (1%)	
13.	Trans Alta Utilities Corporation	UTL	2	005	2	P	C		32	3	25	0	5 Seebe	1975	1988	Clean-up undertaken.	Dry electrical equipment, dry form. wood preserv., wood, rags, scrap metal, etc.	Material has been excavated and placed in steel drums. Site to be backfilled.
14.	CIL Inc.	CBP	1	004	1	P	C		0	5	22	26	4 Carseland	1976	1979	(84-WL-077)	Construction debris.	

Table 20

INDUSTRIAL WASTE LANDFILL PROGRAM
HELP AND LANDFILL POLLUTION, (I.W.L.P.)

INDUSTRIAL LANDFILL MANAGEMENT CONTROL SYSTEM

	COMPANY	TYPE	SUB	GRP	L/F #	L/F LIC	L/F STAT	STATUS	SECT	TWP	RGE	W/M	AREA	OPER FROM	OPER TO	OVERALL COMMENTS	WASTE TYPES	DESIGN & OPERATION
15.	Conoco Ltd.	CHP	1	003	2	Y	O		30	6	22	26	4	Carseland	1981	1985	(83-WL-117)	Construction debris.	
16.	Conoco Ltd.	CHP	1	003	1	P	C		35	6	22	26	4	Carseland	1976	1981	(83-WL-117)	General refuse, construction debris.	
17.	Canadian Western Natural Gas Co.	BCP	2	204	1	P	C		8	8	11	11	4	Bow Island	1935	1977	Site was also used by local residents.	General refuse.	
18.	Petro Canada Resources	PUO	3	063	1	P	C		33	10	15	10	4	Med. Hat	1960	1986		Act. carbon, glycol filters, lube oil filters, oily sludges, tank bottoms.	Invest. c/w soil analysis and trenching of landfill undertaken.
19.	Petro Canada Resources	PUO	3	063	2	Y	O		30	10	15	10	4	Med. Hat	1986	0		Treater bay, filters (glycol and lube).	Invest. c/w soil analysis and trenching of landfill undertaken.
20.	Western Canada Steel	MTL	1	002	1	P	O		14	10	24	29	4	Calgary	1964	0	TSH. Urban location. (82-WE-020)	Slag, mill scale, emission dust, brick, construction debris.	
21.	Trans Alta Utilities Corporation	UTL	2	005	4	Y	O		30	10	25	8	5	Seebe	1986	0		Construction debris, volume assumed.	
22.	Trans Alta Utilities Corporation	UTL	2	005	3	P	C		21	10	25	8	5	Seebe	1950	1976	TSH. Reclamation review req'd - some already undertaken.	General refuse, construction debris, oily rags	
23.	Parks Canada	PRO	2	001	1	P	C		35	11	26	12	5	Banff	0	1968	SW1/4. Trade site (82, Leech, 1985).	Dry "trade" wastes.	Originally an abandoned gravel pit.
24.	Domtar Construction Materials	ABC	1	033	1	P	A		34	13	23	29	4	Calgary	1959	1986	Closed file 090868. Closed wallbd plt. 1805-30 Ave SE. Other owner prev. to '59.	Off spec wallboard, waste gypsum rock, dust, wastes from CPR also.	Infilling of low lying area. Review of site indicates no problems at present.
25.	CIL Calgary Explosive Works	ABC	1	003	1	P	A		32	12	23	1	5	Calgary	1962	1966	HG. Area known as sugar loaf. Site decommissioned & all haz. wastes removed.	Mercuric sulphide sludges, general refuse, empty barrels.	DSA by Monenco. All merc. contam. soils with concentrations >1ppm were removed.
26.	Western Co-operative Fertilizers Ltd.	CHP	1	009	1	P	O		21	16	23	29	4	Calgary	1970	0	HG. Facility is being shut down for an undetermined period. (83-WL-088)	V205 catalyst, sulp., crushed barrels, slack wax possibly MEA reclaimer bottoms.	Built into gypsum pond, possible plant wide g/w monitoring.
27.	Western Co-operative Fertilizers Ltd.	CHP	1	009	2	P	C		21	16	23	29	4	Calgary	1977	1983	HG. Facility is being shutdown for an undetermined period. (83-WL-088)	Sulphur, rubberlined steel, asphalt, timbers, conc., possibly MEA recl. bottoms.	No action indicated, possible plant wide g/w monitoring.

Table 20

INDUSTRIAL WASTE LANDFILL PROGRAM
HELP END LANDFILL POLLUTION, (H.E.L.P.)

INDUSTRIAL LANDFILL MANAGEMENT CONTROL SYSTEM

	COMPANY	TYPE	SUB GRP	L/F ID	L/F LIC	L/F STAT	STATUS	SECT	TWP	RGE	W/M	AREA	OPER FROM	OPER TO	OVERALL COMMENTS	WASTE TYPES	DESIGN & OPERATION
28.	Foothills Steel Foundry	MTL	2 006	1	P	O		10	18	23	28	4	Shepard	1974	0	YSH. Located east of Shepard. Site visited.	Slag, cast sand, emission control dust, mill scale, construction debris.	
29.	Canadian Pacific Railways Ltd.	TRA	1 002	4	P	C		0	20	17	25	4	Ensign	1978	1978	Open from May-June/78. Monitoring wells are destroyed at the site.	Sulphur (1500 tons), covered with limestone.	Limestone added to sulphur top. Some recl. done in '80. G/W mon. wells destroyed
30.	Alberta Rockwool	ARC	1 022	1	P	O		34	20	24	9	5	Canmore	1947	1980	Pile closed 030880. SW20. Used by towing co. Contact W. Hubman, ND. S/V 27/06/88	Slag rock, off spec rockwool, used bbls, some partially full onsite, general.	Wastes in large volumes, used for terrace and road building at site.
31.	Dept. of National Defense	FED	5 004	1	P	C		35	22	15	9	4	Suffield	1948	1985	Officially closed by D.N.D.	Cardboard, hsehold, const., "trade", some unknowns, oil & other liq.-lge. quant.	Site is "mostly" closed. Efforts unsuccessful to date.
32.	Dept. of National Defense	FED	5 004	2	P	O		35	22	15	9	4	Suffield	1983	0	LSD 9 of 22 consisting of several trenches 50m x 12m x 4.5m.	Military & household (paper, wood, metal containers, refuse, etc.) Some unknowns	L/F area (fenced)-approx. 3-4 Ha consisting of trenches lasting about 1 yr each.
33.	Bonco Rock Products Ltd.	NMG	4 005	0	P	O		20	22	28	29	4	Okotoks	1985	0	(85-WL-068)	Waste concrete.	
34.	Lafarge Canada Inc.	NMG	6 001	2	P	C		34	22	24	9	5	Bxshav	0	1974	YSH. No action. (85-WL-164)	Municipal wastes.	Landfill has been capped.
35.	Lafarge Canada Inc.	NMG	6 001	1	Y	O		30	22	24	9	5	Bxshav	1965	0	(85-WL-164)	Kiln dust, waste cement, clinker.	Landfill licensed by Alta. Environment.
36.	Lafarge Canada Inc.	NMG	6 001	3	P	C		34	22	24	9	5	Bxshav	1910	1964	YSH. Abandoned site, no groundwater monitoring. (85-WL-164)	Kiln dust, general refuse, municipal wastes.	Landfill is capped.
37.	Parks Canada	FED	2 001	2	P	O		35	24	25	11	5	Carrot Crk	0	1987	NW1/4. Trade waste site (84, Leech, 1985).	Asphalt, concrete, trade, garden refuse.	Casual usage by nontrade/industrial.
38.	Dome Petroleum Ltd.	HCP	2 046	1	P	C		32	24	15	22	4	Champion	0	1985	LSD 9 of 25. (86-WL-058)	Filters, dessicants, general refuse (95%).	Wastes removed from site.
39.	Steel Brothers Canada Ltd.	NMG	2 001	1	P	C		16	25	24	9	5	Bxshav	1970	1973	NE.-NE 1/4 of 25. Water lic. is currently under review by S&A. (82-WL-042)	Calcium hydroxide, calcium oxide (total = 13 t).	
40.	Canterra Energy Ltd.	HCP	2 027	1	P	C		37	27	20	29	4	Okotoks	1959	1979	SH. Use of neutralizing lime not indicated. (86-WL-141)	Gen. ref., concr., lumber, sulphur bottoms, asbestos, sc. metal-volumes assumed.	G.W. monitoring installed around landfill.

Table 20
INDUSTRIAL WASTE LANDFILL PROGRAM
HELP END LANDFILL POLLUTION, (H.E.L.P.)

INDUSTRIAL LANDFILL MANAGEMENT CONTROL SYSTEM

	COMPANY	TYPE	SUB	GRP	L/F #	L/F LIC	L/F STAT	STATUS	SECT	TWP	RGE	W/M	AREA	OPER FROM	OPER TO	OVERALL COMMENTS	WASTE TYPES	DESIGN & OPERATION
41.	Pan Canadian Petroleum Ltd.	BCP	2	108	1	P	C		35	30	15	21	4	Vulcan	1982	1985	(82-WL-047)	General refuse, anine filters.	Pit is burned.
42.	Cal-Portisan Services Ltd.	SBC	6	001	1	P	O		0	30	23	27	4	Calgary	1975	0	Site is exclusively for disposal.	Sediment from vaccuum truck operations.	
43.	Trans Alta Utilities Corporation	UTL	2	005	8	P	C		35	30	24	10	5	Canmore	1955	1973		Scrap metal	
44.	Trans Alta Utilities Corporation	UTL	2	005	9	P	C		35	30	24	10	5	Canmore	1950	1973		General refuse, trace amounts of septic sludge.	
45.	Canada Cement Lafarge (Bell Pole Co.)	ABC	1	027	1	P	A		0	33	23	29	4	Calgary	0	1979	SW33. Closed file-HPA. Airphotos-post treat. fac. show area with possible wastes	Mainly wood wastes.	Yankage area and large product storage yard. Infilling of low spots.
46.	McKen Contracting (Gulf Refinery)	ABC	1	000	1	P	A		23	26	23	29	4	Calgary	1957	1973	LSD 4 of 36 (Blk. 3/4, Plan 320AH.) Investigation by Govt. reqd.	Oily sludge, spill debris, metals, v. high phenols in one area.	Piezometers & fencing destroyed.
47.	Steel Brothers Canada Ltd.	NHG	2	003	3	P	O		16	36	24	9	5	Bashaw	1965	1985	NG. LSD 1 of 36. Water lic. is currently under review by S&A. (82-WL-042)	Calcium oxide and calcium hydroxide (total = 5485 cu. meters).	
48.	Steel Brothers Canada Ltd.	NHG	2	003	2	P	C		16	36	24	9	5	Bashaw	1965	1985	NG. LSD 2 of 36. Water lic. is currently under review by S&A. (82-WL-042)	Calcium carbonate, calcium oxide (total 4570 cu. meters).	
49.	Canada Creosoting Co. Ltd.	ABC	2	015	1	P	A		0	17	24	1	5	Calgary	1923	1961	Old railway tie treating plant.	Wood, debris, scrap metal, coal slag.	Investigation planned for site.
50.	Nose Creek Wood Preservers	ABC					A			23	24	1	5	Calgary	1952	1964	Old creating plant for poles		G.W. Monitoring installed Evaluation of g.w. undertaken.
51.	Bontar Chemicals Group	WDP	4	002	1	P	C		33	3	26	4	5	Cochrane	1967	1970	TSG. Groundwater monitoring carried out by Alberta Environment. (86-WP-055)	Wood preservative sludge.	G.W. monitoring is present. Evaluation of g.w. carried out.
52.	Bontar Chemicals Group	WDP	4	002	2	P	C		33	3	26	4	5	Cochrane	1969	1969	TSG. Groundwater monitoring carried out by Alberta Environment. (86-WP-055)	Wood preservative sludges.	Groundwater monitoring installed at site.
53.	Bontar Chemicals Group	WDP	4	002	3	P	C		33	3	26	4	5	Cochrane	1968	1968	NG. Groundwater monitoring study currently underway. (86-WP-055)	Wood preservative sludges.	Wastes are in a buried steel tank.
54.	Becker Refinery	ABC	1	032	1	P	A		14	28	18	2	5	Longview	0	0	NW28. Abandoned refinery site. Site visited May 16/88. Landowner Bill Black.	Suspect demolition debris of refinery.	No records. Landowner reports site not a problem. Drainage to north.

Table 20

INDUSTRIAL WASTE LANDFILL PROGRAM
HELP END LANDFILL POLLUTION, (H.E.L.P.)

INDUSTRIAL LANDFILL MANAGEMENT CONTROL SYSTEM

	COMPANY	TYPE	SUB	CAP	L/F #	L/F LIC	L/F STAT	STATUS	SECT	TWP	RGE	W/M	AREA	OPER FROM	OPER TO	OVERALL COMMENTS	WASTE TYPES	DESIGN & OPERATION
55.	Purity 99 Refinery	ABC	1	029	1	P	A	23	4	19	2	5	Blk. Diam.	1954	1954	Gord McDowell (HE-4). L/F at 14-4 near Tongue Crk. HC cont. noted in HcO w/well.	Demolition debris (concrete), buried oil, other unknowns, possibly lead.	Refinery wastes and demolition debris buried beside coulee.
56.	Western Decalta Petroleum	ABC	1	025	1	P	A	34	0	20	2	5	Turner Val	1938	1984	Old gas plt. To be taken over by Dept. of Culture-will be assessing site with AE		Preliminary assessment by Monenco Engineering.
57.	Nova, An Alberta Corporation	BCP	6	008	3	P	C	31	0	20	3	5	Turner Val	1969	1986		General refuse, paper, rags.	Site reclaimed.
58.	Esso Resources Canada Ltd.	BCP	2	052	1	P	C	27	4	20	4	5	Quirk Crk.	1971	1978	SG. Site composed of 3 cells. Include in W.L. (84-WL-150)	Sulphur wastes, dam. barrel, gen. ref., const. deb, filter cartridges, oily rags	Monitoring wells, runoff diversion.
59.	Burnco Rock Products Ltd.	MNG	4	005	4	P	C	35	2	22	1	5	Calgary	1980	1984	Contractors hauled wastes to these landfills under Burnco's supervision.	Broken concrete and asphalt.	Site has a clay and topsoil cover.
60.	Burnco Rock Products Ltd.	MNG	4	005	3	P	C	35	2	22	1	5	Calgary	1980	1984	Contractors hauled wastes to these landfills under Burnco's supervision.	Broken concrete and asphalt.	Site has a clay and topsoil cover.
61.	City of Calgary (Esso Petroleum)	ABC	1	001	1	P	A	12	36	23	1	5	Calgary	1950	0	HG. Site undergoing a detailed invest. to determine what actions are required.	Spent lead oxide (lead sulphate).	Since discovery, a 1.8m chain link fence was installed around the installation.
62.	Cominco Ltd., Calgary Nitrogen Operation	CHP	1	002	1	P	C	35	26	23	1	5	Calgary	1942	1983	(83-WL-075)	Construction debris, paper.	
63.	Cominco Ltd., Calgary Nitrogen Operation	CHP	1	002	2	P	C	35	26	23	1	5	Calgary	1942	1965	(83-WL-075)	Plastic bags, scrap metal, cement.	
64.	Cominco Ltd., Calgary Nitrogen Operation	CHP	1	002	3	P	C	35	26	23	1	5	Calgary	1942	1972	(83-WL-075)	Cobalt/moly and zinc oxide catalyst, possibly Na2CO3.	Some material removed and deep buried under road.
65.	Cominco Ltd., Calgary Nitrogen Operation	CHP	1	002	4	P	C	36	26	23	1	5	Calgary	1985	1985	SG. Insufficient neutralizing material. (83-WL-075)	Elemental sulphur and earth mix (75 t), possible Na2CO3.	Alta. Env. is currently monitoring the situation.
66.	Ace Salvage Ltd.	SEC	5	001	1	P	O	20	0	23	1	5	Calgary	1987	0		Ash, concrete, construction debris.	Removal of waste occassionally to City of Calgary.
67.	Burnco Rock Products Ltd.	MNG	4	005	7	P	O	20	35	23	1	5	Calgary	1987	0	Contractors haul wastes to site under Burnco's supervision. (82-WL-154)	Broken concrete.	

Table 20
INDUSTRIAL WASTE LANDFILL PROGRAM
HELP END LANDFILL POLLUTION, (H.E.L.P.)

INDUSTRIAL LANDFILL MANAGEMENT CONTROL SYSTEM

	COMPANY	TYPE	SUB	GRP	L/F ID	L/F LIC	L/F STAT	STATUS	SECT	TWP	RGE	W/M	AREA	OPER FROM	OPER TO	OVERALL COMMENTS	WASTE TYPES	DESIGN & OPERATION
68.	Canadian Pacific Railways Ltd.	TRA	1	002	1	P	C	0	12	24	1	5	Calgary	0	1970	Located at the Alyth Trainlag Center. Initial start date unknown.	Construction debris, used timber ties.	Some excavation when trainlag center was built.
69.	Canadian Pacific Railways Ltd.	TRA	1	002	2	P	C	0	11	24	1	5	Calgary	0	1970	Initial start date unknown. Currently site of the East Intermodal Services Yard.	Construction debris, used timber ties.	
70.	Duraco Rock Products Ltd.	MNG	4	005	5	P	O	20	29	24	2	5	Calgary	1980	0	(85-WL-031)	Waste concrete.	
71.	Duraco Rock Products Ltd.	MNG	4	005	6	P	C	35	29	24	2	5	Calgary	0	0	(85-WL-031)	Waste concrete.	Site has a backfill cover.
72.	Blairex Dev. (Stearns Catalytic)	ABC	1	015	1	P	A	14	4	24	2	5	Calgary	0	0	NV of 4. Disc. with Alta. Env. has occurred on this site.	Clay mixed with lime at 9:1 ratio & lime slurry into landfill.	Close to Elbow River.
73.	Transport Canada	TRN	4	001	1	P	C	11	13	25	1	5	Calgary	1958	1985	Landfill depth estimated from site photos.	Trade, some industrial, concrete, metals, plastics, wood.	Filling in of natural depression.
74.	Duraco Rock Products Ltd.	MNG	4	005	1	P	O	20	5	25	2	5	Calgary	1985	0	Contractor used site under Duraco's supervision. (81-WL-130)	Broken concrete and asphalt.	
75.	Duraco Rock Products Ltd.	MNG	4	005	2	P	C	35	5	25	2	5	Calgary	0	0	(81-WL-130)	Broken concrete and asphalt.	
76.	Trans Alta Utilities Corporation	UTL	2	005	10	P	O	11	6	25	2	5	Bearspaw	1986	0	TSH. Company intend to close site.	Oily/greasy rags, paper, general refuse, construction debris. Volumes assumed.	
77.	Trans Alta Utilities Corporation	UTL	2	005	11	P	C	34	6	25	2	5	Bearspaw	1955	1986	TSH. No action.	Oily/greasy rags, paper, general refuse, const. debris. Volumes assumed.	
78.	Shell Canada Ltd.	RCP	2	003	1	P	O	30	23	25	5	5	Cochrane	1968	0	TSG. Groundwater monitoring, leachate collection and treatment. (85-WL-115)	Sc. iron, iron sulph, filt. socks, recl. bottoms, catalysts, alum, lime, zeolite	Leachate collection and treatment.
79.	Shell Canada Ltd.	RCP	2	003	2	P	C	26	23	25	5	5	Cochrane	1952	1960	TSG. Plant wide groundwater monitoring, landfill outside of fence. (85-WL-115)	Wood, catalysts, iron sulphide, amine filters	
80.	Shell Canada Ltd.	RCP	2	003	3	P	C	26	23	25	5	5	Cochrane	1952	1960	TSG. Covered under plant wide survey. (85-WL-115)	Sewage, tank sludges, wash water, waste amine, glycols, caustic	
81.	Shell Canada Ltd.	RCP	2	003	4	P	C	26	23	25	5	5	Cochrane	1960	1967	BG. Landfill associated with plant with groundwater monitoring. (85-WL-115)	Amine recl. bottoms, iron sulph., catalysts, molecular sieves, filters, sc. iron	

Table 20

INDUSTRIAL WASTE LANDFILL PROGRAM
HELP END LANDFILL POLLUTION, (I.W.L.P.)

INDUSTRIAL LANDFILL MANAGEMENT CONTROL SYSTEM

	COMPANY	TYPE	SUB	GRP	L/F #	L/F LIC	L/F STAT	STATUS	SECT	TWP	RGE	W/M	AREA	OPER FROM	OPER TO	OVERALL COMMENTS	WASTE TYPES	DESIGN & OPERATION
82.	Shell Canada Ltd.	BCP	2	003	5	F	C	26	23	25	5	5	Cochrane	1965	1980	(85-WL-115)	Soil, alum/lime dewatered sludge	
83.	Shell Canada Ltd.	BCP	2	003	6	F	C	35	23	25	5	5	Cochrane	0	0	(85-WL-115)	Possible amine residues (from amine exchange tube bundles)	
84.	Canron Inc.	ABC	1	031	1	F	A	0	2	26	4	5	Cochrane	0	0	Old cement pipe manufacturing facility. Formerly Anthes operation.	Cement debris, slurry.	Site determined to be of low concern.
85.	Alberta Natural Gas Co. Ltd.	BCP	2	002	1	F	C	35	16	26	4	5	Cochrane	1969	1983	(84-WL-106). NE1/4 of 16.	Construction debris.	Site capped.
86.	Petro Canada Inc.	BCP	2	076	1	F	C	35	16	26	5	5	Cochrane	1969	1979	TSG. Landfill specific groundwater monitoring, Piteau & Associates. (84-WL-078)	Sulphur, act. alum. catalyst, charcoal, asbestos, ir. sulph , paint cans, drums	
87.	Petro Canada Inc.	BCP	2	076	2	F	C	35	16	26	5	5	Cochrane	1961	1969	SG. Co. has mon. wells downgradient of sulp/ir. sulphate waste site. (84-WL-078)	Sulphur, act. alum. catalyst, charcoal, asbestos, ir. sulph, paint cans, drums	
88.	Petro Canada Inc.	BCP	2	076	3	F	C	35	16	26	5	5	Cochrane	1961	1971	(84-WL-078)	Old concrete sulphur stack, activated alumina catalyst, silica gel, charcoal	
89.	Trans Alta Utilities Corporation	UTL	2	005	14	F	O	20	18	26	5	5	Ghost Lake	1986	0		General refuse (90%), construction debris, oily rags. Volumes assumed.	
90.	Trans Alta Utilities Corporation	UTL	2	005	15	F	C	35	18	26	5	5	Ghost Lake	1955	1986		General refuse, construction debris, oily rags. Volumes assumed.	
91.	Petro Canada Inc.	BCP	2	076	4	F	C	35	16	26	5	5	Cochrane	1966	1966	SG. Co. has mon. wells downgradient of buried sulp. & sulp. stack. (84-WL-078)	Sulphur, concrete.	
92.	Amoco Canada Petroleum Co. Ltd.	BCP	2	006	1	F	C	35	14	28	1	5	Crossfield	1966	1975	(85-WL-007)	Gen. ref., const. deb., filt. (lube, sulphinol, glycol, solv.). Vol assume large	Site reclaimed and revegetated.

CALGARY CITY BOUNDARY
HWY. #2
HWY. #1
ELBOW RIVER
GLENMORE RESERVOIR
HWY. #22
LEGEND:
FLUVIAL DEPOSIT (GRAVELS)
TERTIARY UNDIVIDED GRAVEL
CONTAMINATED INDUSTRIAL SITES
CLEAN WATER LICENCE HOLDER WITH GROUNDWATER MONITORING
CLEAN WATER LICENCE HOLDER NO GROUNDWATER MONITORING
NO CLEAN WATER LICENCE (WATER LICENCE EXEMPT)
ABANDONED LANDFILL

Figure 11

Table 21

CONTAMINATED INDUSTRIAL SITES

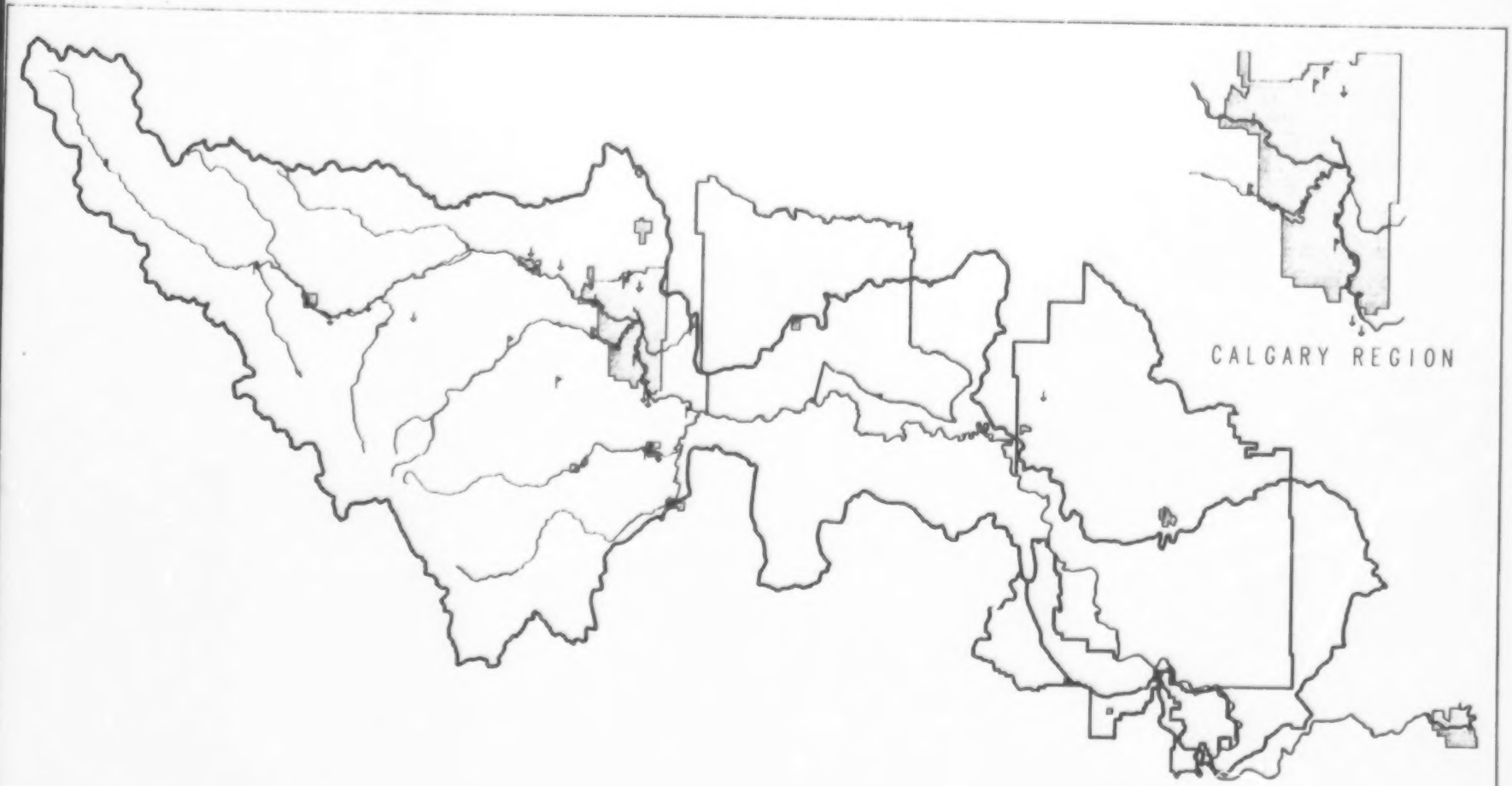
IDENTIFIER	COMPANY NAME	LOCATION	FACILITY	FILE #	STATUS
1.	DOMTAR (CANADA CREOSOTE)	NE17-24-1-W5	WOOD PRESERVING	-	UNDER INVESTIGATION - REMEDIAL MEASURES PLANNED.
2.	BAVARION LION (FIRE PARK)	NE13-24-1-W5	PCB STORAGE		CLEANUP UNDERTAKEN AND SITE RECLAIMED.
3.	PETRO-CANADA (GULF ASPHALT PLANT)	12-24-1-W5	ASPHALT PLANT AND STORAGE TERMINAL	260-002-01	ONGOING CONTAMINANT RECOVERY AND CLEANUP.
4.	CPR - ALYTH YARDS	NW1-24-1-W5	STORAGE	100-021-01	MAJOR SPILLS ONSITE. UNDER INVESTIGATION. REMEDIAL WORK UNDERTAKEN.
5..	ESSO RESOURCES CANADA (IMPERIAL OIL) PROPERTY NOW OWNED BY CITY OF CALGARY	NW36-23-1-W5	REFINERY (ABANDONED)	241-011-01	MAJOR WORK UNDERTAKEN TO CONTAIN SEEPAGE OF HYDROCARBONS.
6.	REFERRED TO AS OGDEN - SOUTH OF IMPERIAL OIL	SE36-23-1-W5	STORAGE		MAJOR PIPELINE SPILL IN 1970. RECOVERY ONGOING.
7.	REFERRED TO AS OGDEN CPR SHOPS	SW33-23-29-W4	STORAGE		WASTE SLUDGE PITS RECLAIMED IN LATE 1970'S, HOWEVER, FURTHER CONTAMINATED AREAS SUSPECTED.

2.3.7 Golf Course Database Overview

At present, there are 45 golf courses existing or under construction in the Bow River Basin (Figure 12). Alberta Environment has an ongoing monitoring program to assess the effect of golf courses on surface water and groundwater quality. Three golf courses are being monitored in the Bow River Basin - Kananaskis, Glencoe, and Calgary Golf and Country Club. The primary focus of the monitoring program is pesticides, although nutrients are also being assessed at Glencoe and Calgary Golf and Country Club.

Each golf course was monitored twice during 1990; four more sets of samples will be collected in 1991. Surface water and sediment samples were collected from adjacent streams (Kananaskis River and Elbow River) at sites upstream and downstream of the golf courses; at Glencoe, water samples were also collected from an outfall draining the golf course.

To date, none of the pesticides analyzed have been detected in water or sediment samples at any of the sites. In addition, there were no differences in nutrients levels between sites upstream and downstream of the golf courses, and levels in the outfall were not higher than in the rivers.



Legend

- Proposed golf course
- Existing golf course

Figure 12

Golf Courses in the Bow River Basin

Produced by EMA
November 1991

Bow River
WATER QUALITY
TASK FORCE

2.4 TASK FORCE BACTERIA SAMPLING PROGRAM

The Eastern Irrigation District maintains a sampling program to monitor coliform bacteria levels of the Bow River at its diversion works. On several occasions per year, fecal coliform levels rise over the 200 counts/100 mL objective for irrigation water (Figure 13). These high bacterial levels often corresponded to heavy rainfalls at the City of Calgary. Thus, there was concern that storm sewer runoff from the City of Calgary is adversely affecting water quality in the Bow River as far downstream as Bassano. There was not, however, sufficient data available to identify the source of the high coliform levels.

The Bow River Water Quality Task Force designed a short-term monitoring program to further investigate this problem. Water samples were collected at frequencies ranging from three to six days per week from July to October 1991. Samples were collected from four sites: upstream of Calgary at the Bearspaw Water Treatment Plant, immediately downstream of Calgary at Highway 22X, at the Carseland Bridge, and at the Bassano Diversion.

As shown in Figure 14 and summarized in Table 22, fecal coliform levels are low upstream of Calgary, increase markedly immediately downstream of Calgary, and then decrease rapidly with distance along the river. The high coliform levels immediately downstream of Calgary are a result of loading from Calgary's sewage treatment plants. The decline in levels downstream of Calgary reflects the decay of fecal coliforms in surface water.

During this study, there were too few storms to statistically evaluate the impact of storm sewer runoff from Calgary on downstream water quality. A qualitative inspection of the data does indicate, however, that coliform levels at Bassano generally increase following rainfalls at Calgary (Table 23). In contrast, coliform levels at the sampling sites upstream and immediately downstream of Calgary did not generally increase following storms.

These findings suggest that the cause of the high storm-related coliform levels at Bassano may be due to factors other than loading from Calgary's storm sewers. Other factors that should be considered include decreased rates of bacterial decay resulting from increased river turbidity following storms, and other sources of fecal coliform loads to the river between Highway 22X and Bassano. In addition, direct fecal coliform loading from Calgary's storm sewers cannot yet be discounted as a source of the high coliform levels at Bassano. Rainfall and storm sewer runoff patterns are complex. It may be that the low values recorded at Highway 22X following the August 11-13 and August 25 storms were a result of samples collected when storm sewer runoff was minimal. In any case, an intensive monitoring program is required to identify the source(s) of the high storm-related coliform levels at Bassano.

EASTERN IRRIGATION DISTRICT

WATER QUALITY READINGS - 1991

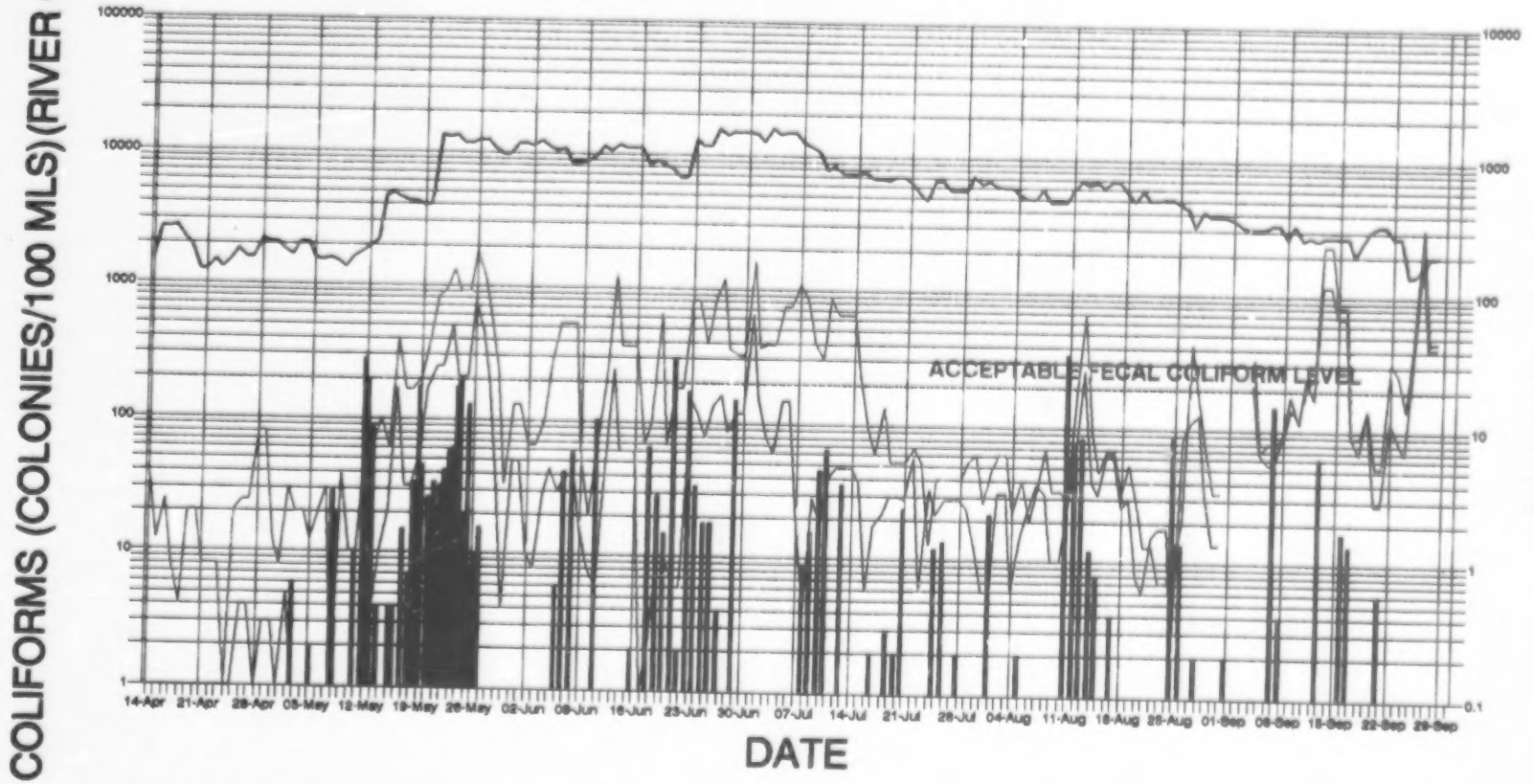


FIGURE 13

Table 22. Fecal Coliforms in the Bow River - July to October 1991.

	Upstream Calgary	Highway 22X	Carseland Bridge	Bassano Diversion
Number of Samples	79	35	32	98
Minimum	1	110	9	2
Maximum	80	6800	5340	2048
Median	7	1450	190	48

FIGURE 14. BOW RIVER FECAL COLIFORMS
TASK FORCE SAMPLING PROGRAM (1991)

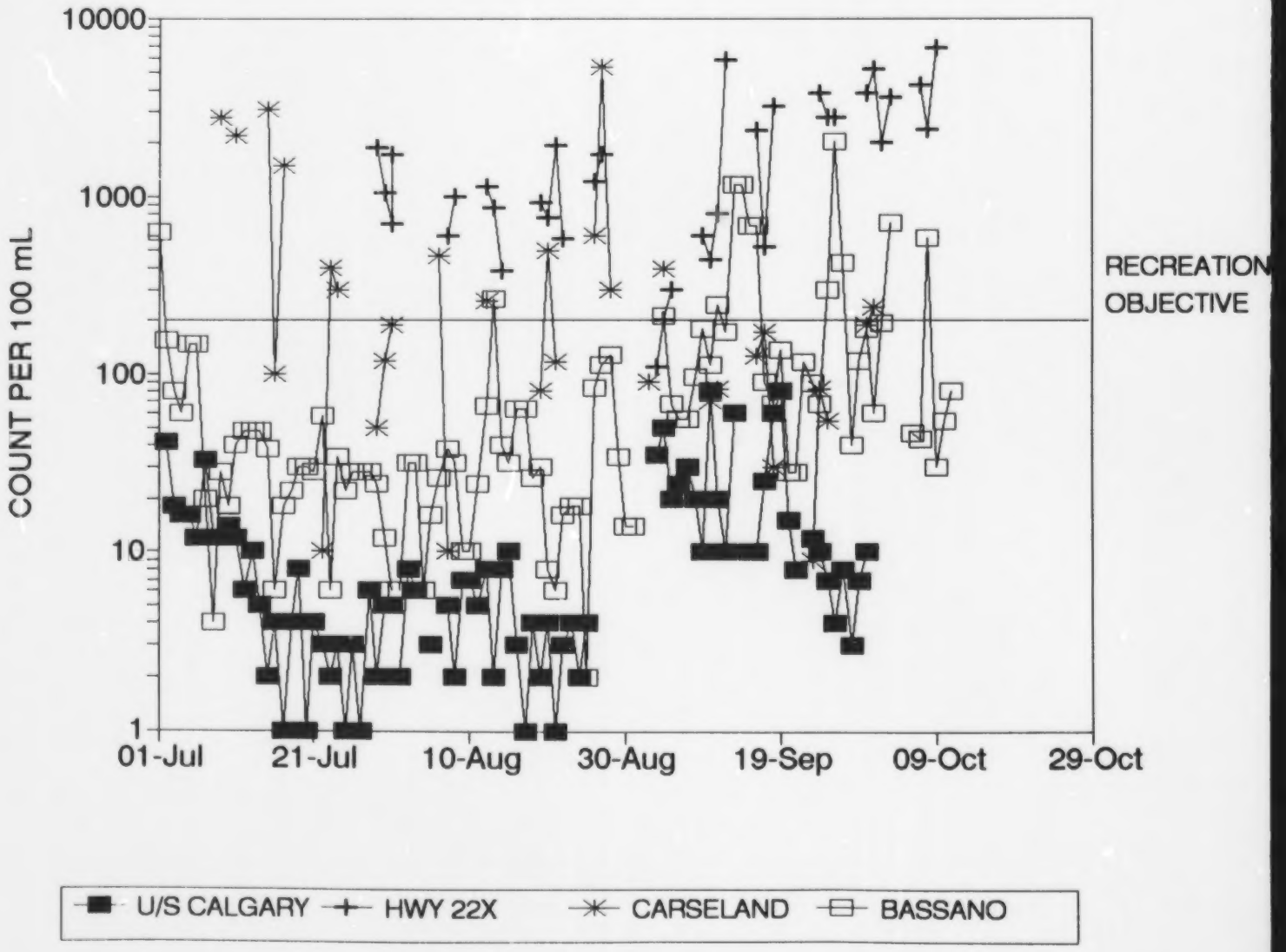


Table 23. Response of Fecal Coliform Levels in the Bow River to Calgary Storms of Greater than 5 mm Rainfall (1991 data).

Date	Rain (mm)[1]	Upstream	Highway 22X	Carseland	Bassano
10 July 11 July	4.6 6.6	None	N/S	N/S	None
11 August 12 August 13 August	34.6 7.6 8.4	None	None	N/S	High Values Aug 12, 13
25 August	8.8	None	None	High Value Aug 27	High Values Aug 25, 28
7 September	15.0	None	N/S	N/S	High Values Sept 9-11
13 September	6.2	High Value Sept 13	N/S	N/S	High Values Sept 13-16

N/S - Not Sampled

[1] Rainfall at Calgary International Airport, Environment Canada

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3.0 SOURCES OF POLLUTANTS

3.1 Municipal and Industrual Effluents

Municipal and industrial discharge of wastewater is licensed by Alberta Environment, and the effluent quality and quantity is monitored as part of the licensing requirements.

There are approximately 50 licensed municipalities and four industries presently discharging wastewater within the Bow River Basin. Details of the municipal wastewater treatment systems (population, receiving water, type of treatment) and industrial effluents (flows, quality, loads) have been presented to the Task Force by Alberta Environment and are summarized in Tables 24 to 26.

Sewage discharge from the City of Calgary is by far the largest point-source (by volume) of effluent within the Bow River Basin. It contributes nearly 90% of the total volume from municipal and industrial effluents that discharge directly into the Bow River and its tributaries. Similarly, loads of all variables listed in Table 26 are higher from Calgary sewage than the other municipal and industrial sources combined.

Table 24. Flows and Receiving Water of Major Municipal and Industrial Effluents in Bow River Basin

LOCATION	REACH	FLOW (m^3/year)	TIMING [1]	RECEIVING WATER
MUNICIPALITY				
Lake Louise	2			
Banff	2	3,650,000	C	Bow River
Canmore	3	1,840,000	C	Bow River
Deadman's Flats	3	64,600	C	Bow River
Barrier Lake	3	20,000	1	Kananaskis River
Kananaskis	3	29,700	C	Kananaskis River
Fortress	3	12,800	2	
Exshaw	3	66,800	C	Bow River
Seebe	3	9,100	1	
Cochrane	3	701,000	C	Bow River
Crossfield	4	200,000	C	Nose Creek
Calgary	5	145,500,000	C	Bow River
Turner Valley	6	201,000	C	Sheep River
Longview	6	60,200	C	Highwood River
Okotoks	6	968,000	C	Sheep River
High River	6	1,310,000	C	Frank Lake
Black Diamond	6	101,000	2	Sheep River
Carseland	7	178,000	1	Bow River
Strathmore	7	576,000	1	Eagle Lake
Gleichen	7	10,900	2	Bow River
Standard	7	57,300	1	Chimney Hill Creek
Milo	7	10,000	1	Slough
Hussar	7	14,700	1	Dead Horse Lake
Bassano	8	129,000	C	Slough
Scandia	8	38,000	1	Bow River
Tilley	8	40,900	1	E.I.D. Canal
INDUSTRY				
Canada Cement Lafarge Ltd.	3	71,800	C	Bow River
Alberta Natural Gas Company Ltd.	3	9,360	C	Bow River
Shell Canada Ltd.	3	98,700	C	Jumping Pound Creek
Cominco Ltd.	5	8,900,000	C	Bow River

[1] Discharge once per annum (1), twice per annum (2), or Continuous (C)

Table 25. Water Quality Characteristics of Municipal and Industrial Effluents within the Bow River Basin

VARIABLE	MUNICIPAL SEWAGE [1]	INDUSTRIES [2]
Suspended Solids (mg / L)	10	8 - 24
Dissolved Nitrogen (mg / L)	15.1	0.07 - 26
Total Phosphorus (mg / L)	0.85	0.02 - 7.8
Fecal Coliforms (CFU / 100 mL)	13,500 [4]	-
Phenolic Compounds (mg / L)	0.01	0.001 - 0.003
Oil and Grease (mg / L)	0.9	0.5 - 1.3
Aluminum (mg / L)	0.7	0.04 - 0.17
Arsenic (mg / L)	0.0004	0.0007 - 0.07
Cadmium (mg / L)	0.002	0.001 - 0.005
Chromium (mg / L)	0.007	0.002 - 0.017
Cobalt (mg / L)	< 0.0001	0.0015 - 0 0035
Iron (mg / L)	0.063	0.17 - 1.0
Lead (mg / L)	0.004	< 0.003 - 0.075
Mercury (mg / L)	-	< 0.0001 - 0.0003
Nickel (mg / L)	0.012	0.002 - 0.116
Zinc (mg / L)	0.045	0.0035 - 0.025

[1] Median values from City of Calgary & Bonnybrook Sewage Treatment Plant based on Alberta Environment monitoring data (1985 - 1991)

[2] Range of average values from licensed industrial discharges to Bow River based on Alberta Environment monitoring data (1988 - 1989)

[3] Range of values for storms sampled in 1982, 1988 - 1989 at storm sewers in Calgary by City of Calgary

[4] City of Calgary, unpublished data

Table 26. Total Annual Loads (kg/yr) from Municipal Sewage Effluent Industrial Discharges to the Bow River

VARIABLE	MUNICIPAL		INDUSTRIAL	
	CALGARY	OTHERS	COMINCO Ltd.	OTHERS
Discharge (m^3 / year)	1.5×10^8	6.2×10^8	8.9×10^6	9.1×10^6
Suspended Solids	1.5×10^6	6.2×10^4	2.5×10^3	1.2×10^4
Dissolved Nitrogen	2.3×10^6	9.4×10^4	8.7×10^4	2.4×10^2
Total Phosphorus	1.3×10^5	5,270	1,200	800
Fecal Coliforms (CFU / 100 mL)	2.1×10^{12}	8.4×10^{10}	N/A	N/A
Phenolic Compounds	1,500	62	27	N/A
Oil and Grease	1.4×10^5	5,580	4.5×10^3	1.0×10^3
Aluminum	1.0×10^5	4,340	1,500	140 *
Arsenic	66	2	9	8 *
Cadmium	290	12	9	2 *
Chromium	1,050	43	18	9 *
Cobalt	< 15	< 0.6	13	1 *
Iron	9,450	391	2,000	780
Lead	600	25	N/A	54 *
Nickel	1,800	74	18	12
Zinc	6,750	279	62	12

N/A Not Available
* Loads from Shell Canada Ltd. not available

3.2 Urban Runoff

3.2.1 Impact on River Water Quality

The Engineering Department, City of Calgary has presented an overview of Calgary's storm sewer system to the Task Force. Those details are not repeated here, instead, we have used computer models and empirical relationships to estimate:

(1) average annual runoff volumes and loads of selected parameters generated within the Bow River Basin from urban stormwater runoff, and

(2) the effect of runoff from a typical storm on the water quality of the Bow River downstream of Calgary

Runoff volumes and suspended solids loadings were generated using the continuous simulation computer model QUALHYMO and 30 years of recorded rainfall data. The model was calibrated to outfall G13, which drains to Glenmore Reservoir.

Both runoff volumes and suspended solids loadings vary with land use, with the highest volumes and loads generated from commercial and industrial areas and the lowest in rural or undeveloped (parkland) areas (Table 27). Storm sewer drainage areas and land uses are shown in Figure 15. Based on land uses within each of the major storm drainage systems and the three reaches affected by Calgary's storm sewers, average annual runoff volumes and suspended solids loads were estimated (Table 28).

Runoff from other municipalities within the Bow River Basin was estimated from the loads predicted for Calgary's residential area. The areas contributing urban runoff (in ha) of other municipalities were estimated from 1:250,000 topographic maps (Table 29).

The computer simulation model only provides estimates of suspended solids loads from urban runoff. Loads for other parameters were based on relationships between other contaminants and suspended solids developed in previous studies or average concentrations reported in storm sewer fecal runoff from the City of Calgary (Tables 30 and 31).

The effect of a typical evening thundershower on fecal coliform levels in the Bow River downstream of Calgary is shown in Table 32. Sediment loadings are highly dependent on the time before a rainfall of previous storms, as it is during that time that sediment (and other contaminants) build up on city streets. The computer model was used to simulate sediment loads and runoff volumes for a storm on 17 September 1989 when 5 mm of rain fell on the City of Calgary. That storm resulted in a sediment loading of 14 kg/ha and a runoff volume of 15 m^3/ha. If we assume that storm sewers discharged for four hours following the storm (a realistic time period based on observations of storm discharge to Glenmore Reservoir), and that the rainfall was constant across the entire city, then a total of 772,500 m^3 would have drained directly into the Bow River through storm sewers (outfalls draining to WID canal and Elbow River (upstream of Glenmore Reservoir) were excluded. If we assume that the rate of storm sewer discharge to the Bow River is constant over that 4-hour period, then the average rate of flow (from all storm sewers combined) is 54 m^3/s.

The predicted fecal coliform bacteria counts immediately downstream of Calgary would range from 340 CFU/100 mL at high river flows to 780 CFU/100 mL at low flows (Table 32). However, it is well known that fecal coliform bacteria decay quickly once they enter surface waters. Assuming a decay rate of 90% per day, it is apparent that the majority of fecal coliforms from sources at Calgary (municipal sewage and urban runoff) will not survive past Carseland Weir, and only a portion of the fecal coliforms generated at Calgary will survive as far downstream as Bassano, which is generally more than two days time of travel from Calgary.

The projected bacterial levels at Bassano are, however, considerably lower than that observed at that site, where fecal coliform counts of more than 400 CFU/100 mL have been recorded. The discrepancy between the predicted and observed levels may be a result of failures in the assumptions used to predict downstream concentrations (e.g., fecal coliform survival may increase in turbid waters or first-order decay may not be realistic). Unfortunately, there are too few data available to test the relationship between fecal coliform survival and turbidity of the Bow River. Another potential cause of the higher than projected bacterial levels is input from local sources. Sources that may be contributing to fecal coliforms in the lower portion of the basin are runoff from pasture land and feedlots (especially during heavy rainfalls), and local municipal effluents (e.g., Cluny, Standard, Gleichen).

Table 27. Suspended Sediment Loadings and Runoff Volumes from Generalized Land Uses.

Type of Land use	Suspended Sediment Loadings (kg/ha/yr)	Runoff Volumes (m^3/ha/yr)
Residential Development	1800	1050
Commercial/Industrial or Highly Impervious	2000	2000
Rural or Undeveloped	1500	160

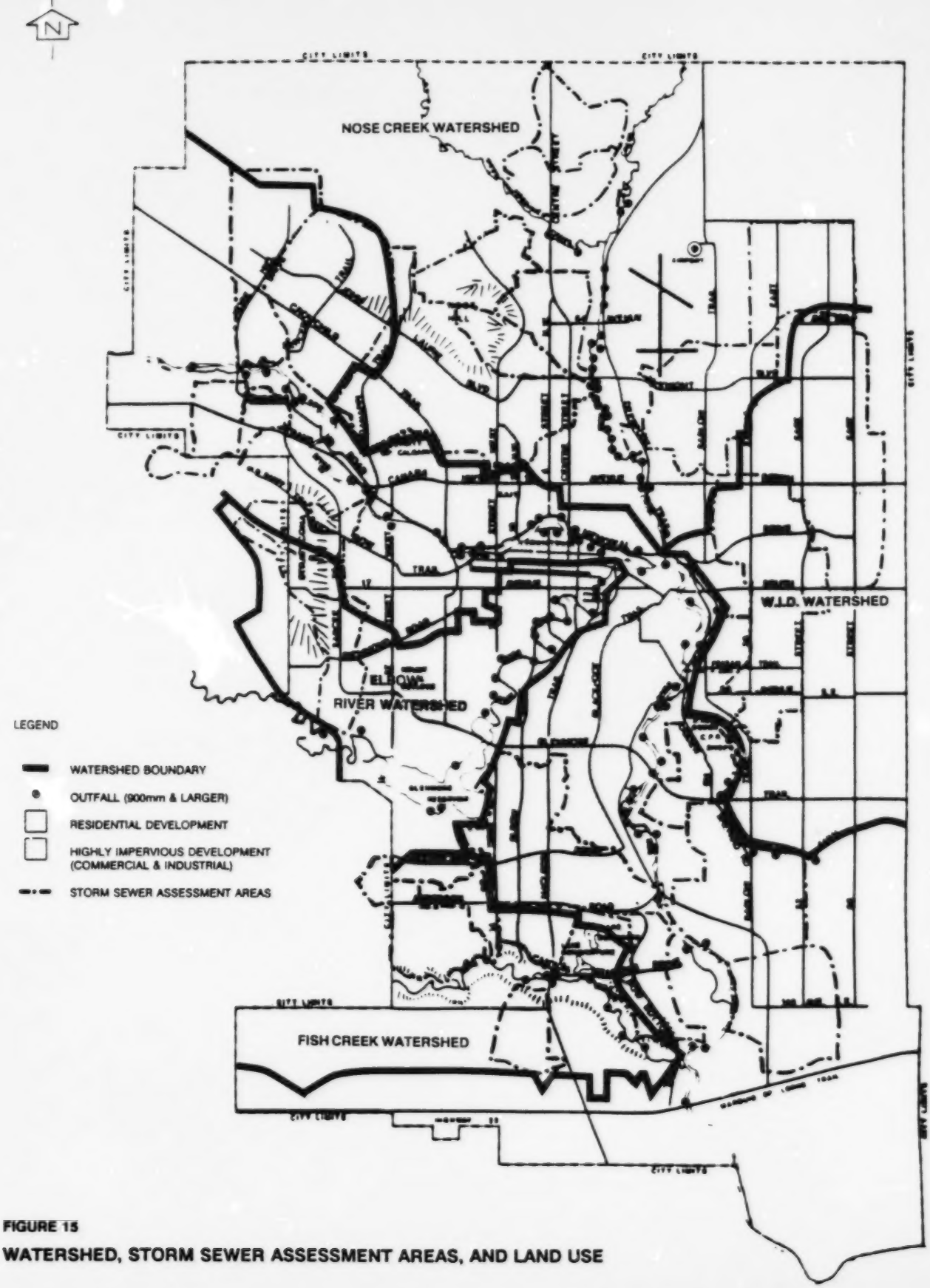


FIGURE 15

WATERSHED, STORM SEWER ASSESSMENT AREAS, AND LAND USE

Table 28. Suspended Sediment Loadings to Bow River within the City of Calgary.

Watershed	Total Area (ha)	Suspended Sediment Loadings (tonnes/year)
STORM SEWER BASINS		
Adjacent to Bow River	32,100	54,000
Nose Creek	14,100	24,000
Elbow River	5,500	9,000
Fish Creek	5,300	9,000
WID Canal	8,500	15,000
REACH NO.		
4 - Bearspaw Dam to WID Canal	35,000	59,000
5 - WID Canal to HWY 22X	15,600	27,000
6 - HWY 22X to Carseland Weir*	6,200	10,000

* NOTE: Sediment loadings to WID canal do not enter Bow River within the City of Calgary.

Table 29. Areas (by reach) Contributing Urban Runoff within the Bow River Basin.

Reach	Area (ha)
1	0
2	550
3	1,475
4	35,800
5	15,600
6	7,600
7	365
8	350

Table 30. Loading Rates Used to Calculate Mean Annual Loads from Urban Runoff.

Variable	Rate (kg/ha/yr)
Suspended Solids[1]	1,800
Total Phosphorus[2]	0.64
Total Nitrogen[2]	16.6
Fecal Coliforms[2] (CFU/100 mL/yr)	8.1×10^5
Cadmium[3]	0.0011
Lead[3]	0.0137
Mercury[3]	<0.0001
Nickel[3]	0.0158
Zinc[3]	0.106

1 Simulated for residential land by QUALHYMO.

2 Estimated from predictive relationships developed for outfall G13, which drains into Glenmore Reservoir (HydroQual Canada Ltd. and JNMackenzie Engineering Ltd. 1991. Technical Memorandum #2. Glenmore Reservoir Stormwater Quality Improvement Study. Phase II. Draft Report. Prepared for City of Calgary, Engineering Department).

3 Estimated from flow-weighted mean concentrations in storm runoff to Forest lawn Stormwater Retention Lake (Hamilton and Chappell. 1984. Recreational Potential and Water Quality Characteristics of a Calgary Stormwater Retention Lake. Alberta Environment and City of Calgary).

Table 31. Average Annual Loads of Selected Water Quality Variables Generated by Urban Runoff in the Bow River Basin.

VARIABLE	REACH (tonnes/year)							
	1	2	3	4	5	6	7	8
Suspended Solids	0	990	2700	59,000	27,000	14,000	660	690
Total Phosphorus	0	0.45	0.9	23	10	5	0.2	0.2
Total Nitrogen	0	9	24	590	260	126	6	6
Fecal Coliforms (CFU/100 mL/yr)	0	4.5×10^5	1.2×10^6	2.9×10^7	1.2×10^7	6.2×10^6	3.0×10^5	3.1×10^5
Cadmium	0	0.0006	0.002	0.04	0.02	0.008	0.0004	0.0004
Lead	0	0.008	0.02	0.5	0.2	0.1	0.005	0.005
Mercury	0	<0.00006	<0.002	<0.044	<0.002	<0.00008	<0.00004	<0.00004
Nickel	0	0.009	0.02	0.6	0.2	0.1	0.,006	0.006
Zinc	0	0.06	0.16	3.8	1.7	0.8	0.04	0.04

Table 32. The Contribution of Municipal Sewage and Urban Runoff to Fecal Coliform Levels Downstream of Calgary following a Typical Storm.

FECAL COLIFORM COUNTS (No./100 mL)			FLOWS (m^3/s)			ESTIMATED FECAL COLIFORM COUNT (No./100 mL) and RIVER TIME OF TRAVEL (days)[7]		
Bow River u/s Calgary[1]	Calgary Sewage Effluent[2]	Calgary Storm Sewer Effluent[3]	Bow River at Calgary[4]	Calgary Sewage[5]	Storm Sewers[6]	Immediately d/s Calgary	Carseland Weir	Bassano Dam
4	13,500	775	75	4.6	54	780 (0)	103 (0.88)	2 (2.7)
4	13,500	775	125	4.6	54	569 (0)	97 (0.77)	3 (2.3)
4	13,500	775	250	4.6	54	340 (0)	82 (0.62)	4 (1.9)

1 Median counts at Cochrane (Sosiak, A.J. 1990. The Bow River Water Quality Monitoring Program 1986 to 1988. Draft Report. Alberta Environment).

2 Bonnybrook Wastewater Treatment Plant, unpublished data.

3 HydroQual Canada Ltd. and JNMackenzie Engineering Ltd. Glenmore Reservoir Stormwater Quality Improvement Study. Phase II. Technical Memorandum #2. Draft. Prepared for Engineering Department, City of Calgary.

4 Low, average, and high flows.

5 Municipal Branch, Alberta Environment, unpublished data.

6 Based on runoff (15 m^3/ha) from a typical storm (5 mm rainfall) over entire portion of City of Calgary that drains directly into Bow River (51,500 ha); the outfalls were assumed to discharge for four hours following the storm.

7 Calculated assuming no other sources of fecal coliforms and a decay rate of 90% die-off after 24 hours (T_{90} = 24 hr).

3.2.2 Stormwater Treatment

An overview assessment of the possibility of providing sedimentation treatment of Calgary's urban stormwater is provided below. These are preliminary, order-of-magnitude estimates only, and must be refined with more detailed analyses.

The City of Calgary was divided into the following areas on the basis for potential for treatment of urban runoff and costs for implementing control measures (i.e., sedimentation facilities):

(1) Existing and future development areas with existing treatment facilities (Figure 16).

These areas include:

Canyon Meadows Golf Course
Confederation Park
"Duck Pond", in Section 33, TP 23, Rge 29
Glenmore Reservoir
Harvest Hills Lake
MacEwan Lake
McCall Lake
68 Street Pond
Willow Park Golf Course

No costs have been attributed to stormwater treatment from these areas.

(2) Existing development areas with potential for on-site (retrofit) treatment facilities.

These areas are shown in Figure 17. A cost of $8,200/ha is estimated for these areas (based on the cost of the Marlborough Park stormwater storage facility in southeast Calgary.

(3) Existing development areas tributary to potential off-site treatment facilities (Figure 18).

For areas along Fish Creek, Nose Creek, and West Nose Creek, costs of $300 - $360/ha are estimated from previous costs for specific impoundments along Nose Creek (associated with the Nose Creek Basin Storm Drainage Analysis). For areas along the Bow and Elbow Rivers, a cost of $1,000/ha is estimated from costs associated with sedimentation facilities determined for Glenmore Reservoir outfalls.

(4) Future development areas.

A cost of $1,700/ha is estimated to treat runoff from future development areas, based on the estimates for the Strathcona Development area pollutant removal sedimentation facility.

(5) Existing areas with no potential for on-site treatmnt facilities (Figure 17).

No costs have been estimated for these areas.

The preliminary cost estimates are summarized in Table 33. Costs for treatment of existing areas are given in Table 34. Approximately 70% of the existing City of Calgary could be provided with urban runoff treatment at a capital cost of about $6,000,000, which is equivalent to $22 per existing lot. These costs are dependent on the acceptability of storage impoundments being constructed along Nose, West Nose and Fish Creeks and the Bow and Elbow Rivers. The feasibility of such impoundments, particularly their non-engineering implications, have not been addressed here.

Future development areas in the current City of Calgary boundaries can be provided with sedimentation treatment at a capital cost of $56,000,000, which is equivalent to about $120/lot. This type of treatment for stormwater runoff is technically feasible; it is currently being implemented for the Strathcona development area in west Calgary.

In addition to areas that are fully developed, high potential sediment washoff loadings occur with developments in their construction phase. Effective sediment control for new development areas is feasible and practical. Past experience in the United States suggests a cost of about $300 per residential lot. This cost is much higher than the costs for long-term treatment of urban runoff, reflecting the much higher pollutant volumes to be addressed during the construction phase.

Implementation of sedimentation facilities not only involves capital costs but also includes ongoing operations and maintenance costs. If effective construction sediment control is implemented, then the long-term costs would be about $2/lot/year. That value is based on costs currently experienced by the City of Calgary for existing facilities plus additional operational and maintenance costs such as trash removal, mowing, etc.

Table 35 provides a summary of anticipated costs for sedimentation treatment of urban runoff for the City of Calgary.

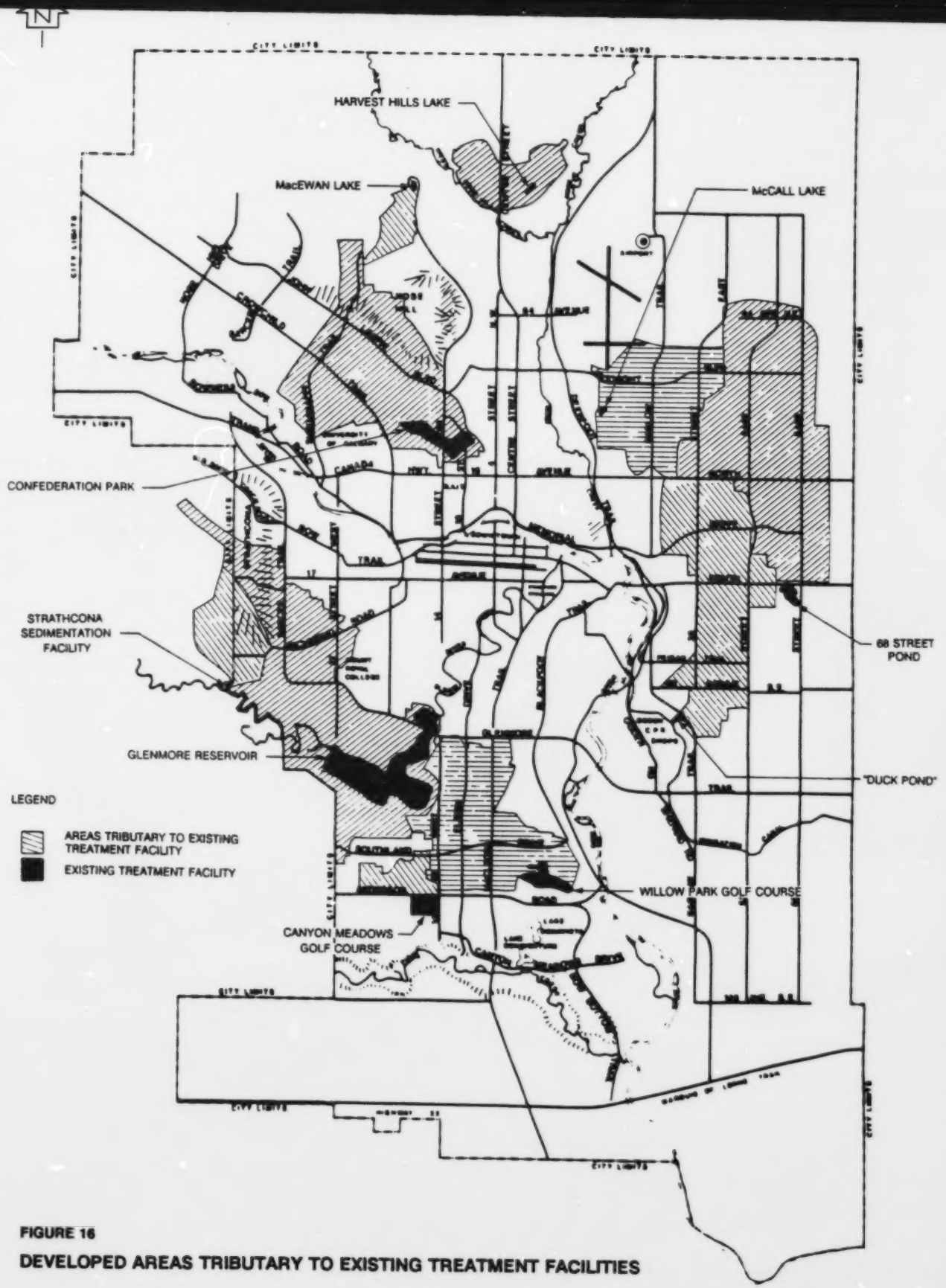
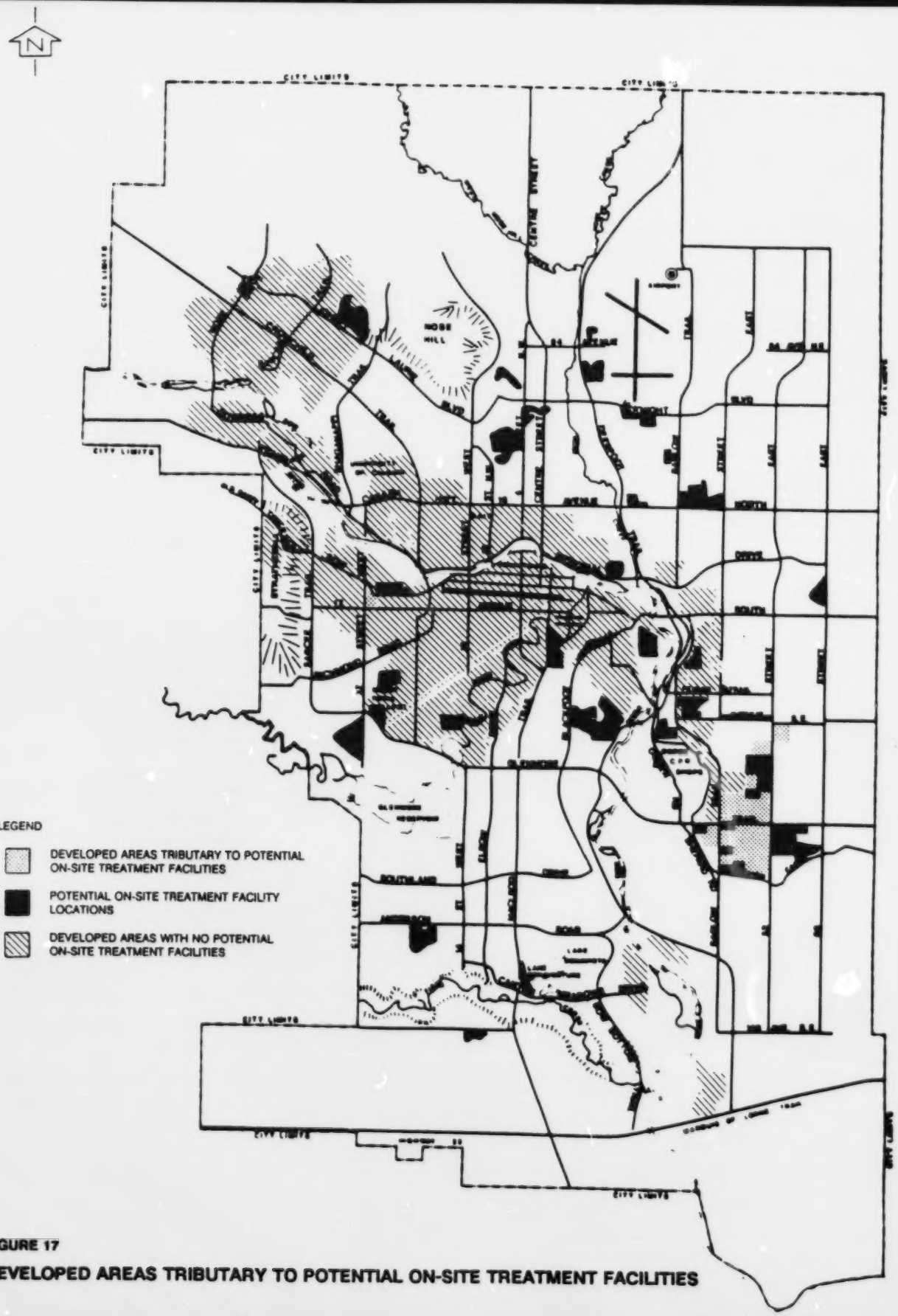


FIGURE 16

DEVELOPED AREAS TRIBUTARY TO EXISTING TREATMENT FACILITIES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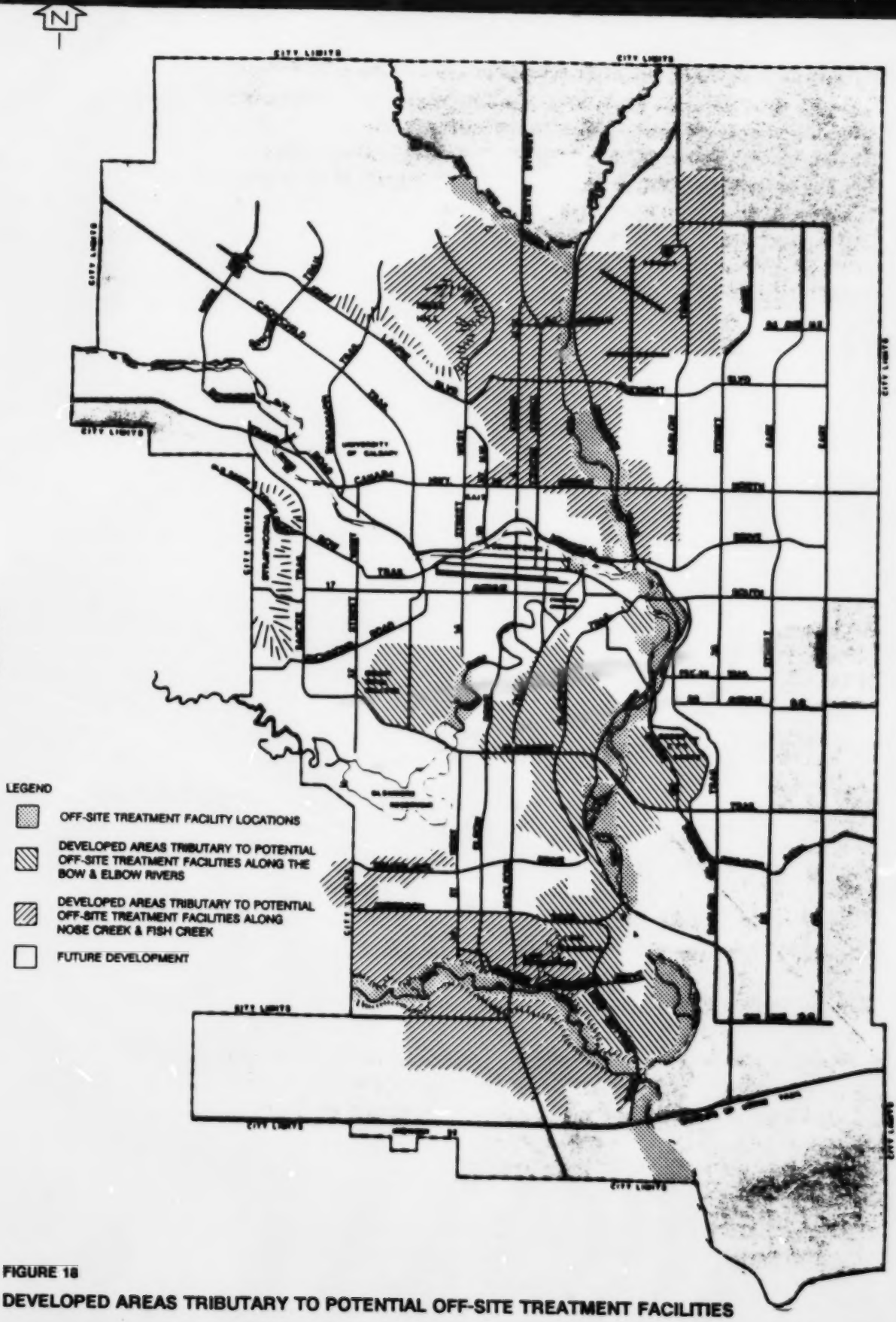
LEGEND
DEVELOPED AREAS TRIBUTARY TO POTENTIAL ON-SITE TREATMENT FACILITIES
POTENTIAL ON-SITE TREATMENT FACILITY LOCATIONS
DEVELOPED AREAS WITH NO POTENTIAL ON-SITE TREATMENT FACILITIES

FIGURE 17

DEVELOPED AREAS TRIBUTARY TO POTENTIAL ON-SITE TREATMENT FACILITIES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LEGEND
OFF-SITE TREATMENT FACILITY LOCATIONS
DEVELOPED AREAS TRIBUTARY TO POTENTIAL OFF-SITE TREATMENT FACILITIES ALONG THE BOW & ELBOW RIVERS
DEVELOPED AREAS TRIBUTARY TO POTENTIAL OFF-SITE TREATMENT FACILITIES ALONG NOSE CREEK & FISH CREEK
FUTURE DEVELOPMENT

FIGURE 18

DEVELOPED AREAS TRIBUTARY TO POTENTIAL OFF-SITE TREATMENT FACILITIES

Table 33. Costs for Calgary Stormwater Treatment.

AREAS OF CITY OF CALGARY	TOTAL AREA (ha)	UNIT COST ($)	TOTAL COST ($)	COST/LOT ($)	% OF TOTAL AREA	% OF TOTAL COST
Existing Development						
Areas with existing treatment facility	12 769	n/a	n/a	n/a	17.8	n/a
Existing developed areas tributary to potential off-site treatment facilities						
- along Nose Creek	3,300	300	1,000,000	25	4.6	1.5
- along Fish Creek	2,777	360	1,000,000	30	3.9	1.5
Existing developed areas tributary to potential off-site treatment facilities along Bow and Elbow Rivers	3,760	1,000	3,800,000	84	5.3	5.7
Existing developed areas tributary to potential on-site (retro-fit) treatment facilities	580	8,200	4,800,000	690	0.8	7.2
Existing developed areas with no potential on-site treatment facilities	8,874	n/a	n/a	n/a	12.5	n/a
Future Development						
Future development tributary to Nose and West Nose Creeks	6,902	150	1,000,000	12	9.7	1.5
Future development (excludes future development to Nose and West Creeks)	32,333	1,700	55,000,000	142	45.4	82.6
TOTAL	71,295		66,600,000		100	100

* Based on 5 lots/acre or 12 lots/hectare.
Assumes all land is developed as residential.

Table 34. Costs for Existing Development Areas.

CITY AREA	CATCHMENT AREA (ha)	CAPITAL COST
Areas with existing treatment facility	12,769	$0
Areas tributary to off-site facilities		
- Nose Creek	3,300	$1,000,000
- Fish Creek	2,777	$1,000,000
Areas tributary to off-site facilities along Bow and Elbow Rivers	3,760	$3,800,000
SUBTOTAL	22,606	$5,800,000
Developed areas with potential for on-site 'retro-fit' facilities	580	$4,800,000
Developed areas with no potential for on-site 'retro-fit' facilities	8,874	n/a
SUBTOTAL	9,454	
TOTAL	32,060	

Table 35. Summary of Urban Runoff Treatment Cost Estimates for Calgary ($/Lot).

Long term treatment for an existing development areas	$22
Long term treatment for future development areas	$120
Construction sediment control for future development areas	$300
Long term operation and maintenance for existing and future development areas	$2

3.3 Agricultural Runoff

The primary issues related to runoff from agricultural land (including pasture, crop, and intensive livestock operations) is the potential impact on nutrient, fecal coliform, and pesticide levels in surface water. A considerable amount of effort has been expended throughout North America on quantifying the amount of these contaminants that are exported from agricultural land to surface water bodies. The result of these studies is the development of export coefficients, which are values indicating the rate of export of material from an area of farmland (or forest) during a specific time interval (e.g., 0.15 kg P/ha/yr).

Although a considerable amount of work has been carried out in other regions, very little information exists on nutrient, fecal coliform or pesticide losses from agricultural lands in the prairies. Similar data deficiencies exist for export coefficients from forested areas and feedlots in areas climatically similar to the Bow River Basin. The most comprehensive compilation of published export coefficients is based on sites in eastern North America, and as a result these values are not directly applicable to the Bow River Basin. Literature based export coefficients for phosphorus, nitrogen and fecal coliforms are summarized in Table 32.

In order to correct the data from eastern North America for climatic differences, the literature coefficients have been multiplied by the following scaling factor (SF):

$$SF = R1/R2$$

where,

R1 = Rainfall erosivity (R) factor for a climate similar to the eastern Bow River Basin. Montana is used because R values have not been derived for Canada.

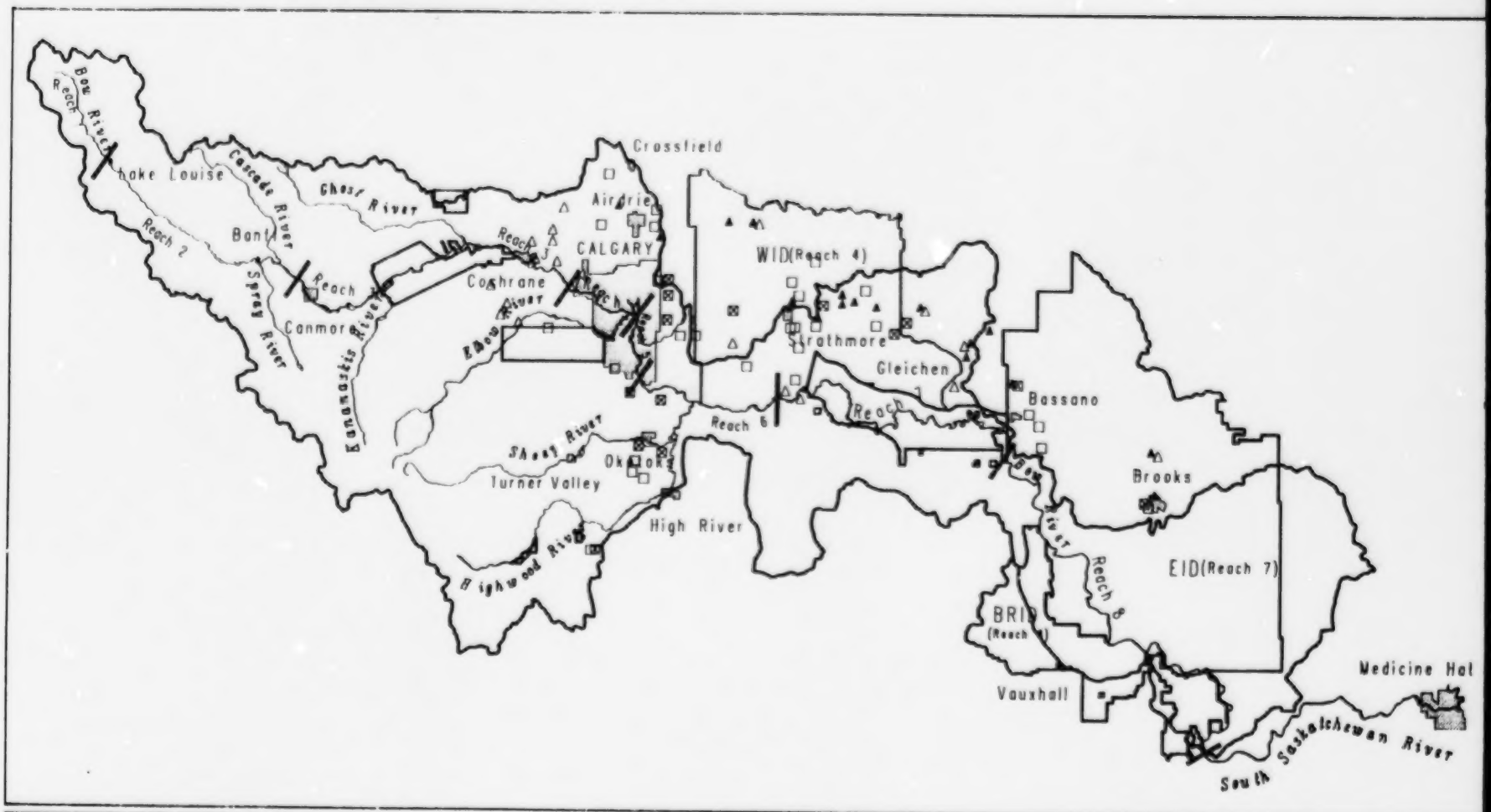
R2 = Mean R factor for the sites used to derive the literature export coefficients.

Rainfall erosivity factors for the U.S. compiled by the EPA and USDA were used to derive values of SF. The adjusted export coefficients are summarized in Table 37 and are similar to values derived for two basins in central Alberta (see Table 36).

Export coefficients selected for the Bow River Basin are presented in Table 38. The export coefficients were chosen based on a comparison of the adjusted literature coefficients and values derived for central Alberta. In general, the values chosen are intermediate between the two sets of values but nearer to the lower of the values.

The areal distribution of agricultural usage within each river reach is given in Table 39 and loads of nitrogen, phosphorus, and fecal coliforms, and 2,4-D in Table 40.

As stated in the July 1991 issue of the Country Guide, "an environmental report released by the Paris-based Organization for Economic Co-operation and Development confirms that Canadian farmers use chemical fertilizers and pesticides sparingly. On average, an acre of arable land gets 7 times more nitrogenous fertilizer in Germany or the U.K. than in Canada, and 5 or 6 times more pesticide. An acre in Japan gets 18 times more pesticide and 5 times more nitrogenous fertilizer. Even in the U.S., each arable acre on average gets twice the pesticide and almost twice the nitrogenous fertilizer of a Canadian acre.



Legend

- Poultry
- Cattle feedlot (over 1000 head)
- Swine
- Dairy cattle (100-200 animals) (40-80 cows)

Figure 19

Feedlot Locations in the Bow River Basin

Produced by EMA
November 1991

Bow River WATER QUALITY TASK FORCE

Table 36. Literature Based Export Coefficients

Parameter	Non-row Crop *	Pasture *	Feedlot *	Forest !	Agric. !	Forest ^	Agric. ^	Feedlot @
Phosphorus (kg/ha/yr)								
Median	0.76	0.81	224.00					
Mean	1.08	1.50	300.70	0.14	0.27	0.10	0.19	250
S.D.	0.77	1.64	226.64					
Nitrogen (kg/ha/yr)								
Median	6.08	5.19	2923.2					
Mean	5.19	8.65	3110.7	2.50	2.13			600
S.D.	2.07	8.86	2400.4					
F. Coliforms (MPN/ha/yr) #	3.5E+09	3.5E+09	6.4E+14					
Concentration (MPN/l)			3.50E+08					

* - Reckhow et al. (1980), mostly from eastern North America
@ - McElroy et al. (1976), midwestern U.S.
# - Ahmed & Schiller (1980), mostly from eastern North America
Feedlot coliform loadings (MPN/ha/yr) = 10000 x RO x Conc x 0.7 (Ahmed & Schiller 1980)
where, RO = Direct surface runoff (375*0.7 mm), Conc. = concentration of Col. (MPN/l)
! - Trew et al. (1985), Baptiste Lake, Alberta
^ - Mitchell (1985), Lake Wabumum, Alberta

Table 37. Literature Based Export Coefficients Adjusted for the Bow River Basin

Parameter	Non-row Crop	Pasture	Feedlot
Phosphorus (kg/ha/yr) *			
Median	0.11	0.12	89.60
Mean	0.16	0.23	120.28
S.D.	0.12	0.25	90.66
Nitrogen (kg/ha/yr) *			
Median	0.91	0.78	1169.28
Mean	0.78	1.30	1244.28
S.D.	0.31	1.33	960.16
F. Coliforms (MPN/ha/yr) #	518700000	518700000	2.6E+14
Scaling Factor **	0.15	0.15	0.4

* - Reckhow et al. (1980), mostly from eastern North America
# - Ahmed & Schiller (1980)
** - Based on difference between Rainfall Erosivity (R) factors (McElroy et al. 1976) for Montana (=Alberta) and sites used by Reckhow et al. (1980) and Ahmed & Schiller (1980)

Table 38. Export Coefficients Selected for the Bow River Basin

Parameter	Agric.	Feedlot	Forest
Phosphorus (kg/ha/yr)	0.15	90	0.10
Nitrogen (kg/ha/yr)	1.50	1000	1.00
F. Coliforms (MPN/ha/yr)	5.2E+08	2.6E+14	

Table 39. Agricultural Usage in the Bow River Basin Area (ha).

Reach	Area (ha)		Intensive Livestock[2]	Number of Head[1]		
	Forests	Farmland[1]		Dairy Cattle	Beef Cattle	Hogs
1	46,000	0	0	0	0	0
2	284,000	0	0	0	0	0
3	391,000	58,000	2	1,050	0	0
4	94,300	106,400	122	600	48,000	3,000
5	17,900	25,600	4	0	1,500	0
6	23,300	227,000	62	0	26,000	0
7	0	502,000	214	750	70,500	19,700
8	0	635,000	95	0	22,000	19,000

[1] Includes both crop and pasture land.

[2] Converted from number of animals to area using the stocking rates given by Ahmed and Schiller (1980). Prog. Wat. Tech. 12: 781-801:

Livestock	Number of Animals/ha of barnyard area
Beef Cattle	420
Dairy Cattle	494
Hogs	445

[3] Source -

Table 40. Forest and Agricultural Loads (kg/yr) of Nutrient, Fecal Coliforms, and 2,4-D to Surface Waters in the Bow River Basin.

Reach	Total Phosphorus			Total Nitrogen			Fecal coliforms (cfu/yr)			2,4-D		
	Forests	Agriculture[1]	Feedlots[2]	Forests	Agriculture[1]	Feedlots[2]	Forests	Agriculture[1]	Feedlots[2]	Forests	Agriculture[1]	Feedlots[2]
1	4,600	0	0	46,000	0	0	2.4×10^{13}	0	0	-	0	-
2	38,000	0	0	280,000	0	0	1.5×10^{14}	0	0	-	0	-
3	39,000	8,700	190	390,000	87,000	2,100	2.0×10^{14}	3.0×10^{13}	5.2×10^{14}	-	520	-
4	9,400	10,000	11,000	94,000	160,000	120,000	4.9×10^{13}	5.5×10^{13}	3.2×10^{16}	-	960	-
5	1,800	3,800	320	18,000	38,000	3,600	9.3×10^{12}	1.3×10^{13}	9.3×10^{14}	-	230	-
6	23,000	34,000	5,600	230,000	340,000	62,000	1.2×10^{14}	1.2×10^{14}	1.6×10^{16}	-	2,000	-
7	0	75,000	19,000	0	750,000	210,000	0	2.6×10^{14}	5.5×10^{16}	-	4,500	-
8	0	95,000	8,600	0	950,000	95,000	0	3.3×10^{14}	2.5×10^{16}	-	5,700	-

[1] Includes both crop and pasture land.
[2] Intensive livestock operations.

3.4 Golf Course Runoff

The primary issue related to the effect of golf courses on water quality is runoff of nutrients and pesticides. Pesticides Monitoring Branch of Alberta Environment is preparing a report on usage patterns and amounts of nutrients and pesticides applied to golf courses in Alberta. The information presented here is based on responses to a questionnaire sent to superintendents or licensed applicators of 91 golf courses in Alberta.

There is very little information on export coefficients of nutrients and pesticides from golf courses. Therefore, we have estimated export coefficients from the application rates and assumed that 10% of the total amount of nutrient or pesticide applied to the golf courses is exported to adjacent surface water bodies. The commonly used pesticides and their average application rates are listed in Table 41.

The 10% export rate is a very conservative estimate based on the percentage of nitrogen exported from agricultural land, i.e., application rates 45-200 kg/ha/yr and export coefficient 1.5 kg/ha/yr gives a proportion of export of 0.8 to 3% of the amount of nitrogen applied to crops.

Total loads of nitrogen, phosphorus, and 2,4-D from golf courses are presented for each reach in Table 42. Compared to other sources of nutrients and herbicides, loadings from golf courses are negligible on a reach-by-reach basis. They may, however, potentially affect small streams or ponds within or adjacent to the course.

Table 41. Application Rates of Nutrients and Commonly-Used Pesticides to Golf Courses in Alberta.

Parameter	Average Amount per 18 Holes per Year (kg)	Percentage of Courses Using
NUTRIENTS		
Nitrogen	2244	100
Phosphorus	355	100
INSECTICIDES		
Malathion	1.5	44
HERBICIDES		
2,4-D	20.5	100
Dicamba	1.6	100
Mecaprop	10.1	89
Glyphosate	1.1	78
Aqua-shade (L)	2.3	56
FUNGICIDES		
Thiram	13.4	78
Quintozene	33.7	67
Cala-chlor		
Mercuric Chloride	7.1	56
Mercurous Chloride	14.3	56
RODENTICIDE		
Styrchnine	2.6	22
Sulphur	5.2	22

Table 42. Golf Course Loadings to the Bow River Basin.

Reach	No. Course	No. Holes	LOADING (kg/yr)		
			TP	TN	2,4-D
1	0	0	0	0	0
2	1	36	70	450	4
3	14	315	620	3900	36
4	24	450	890	5600	51
5	6	117	230	1500	13
6	10	207	410	2600	24
7	5	63	120	790	7
8	2	27	50	340	3